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(September, 1952)

STUDIES ON THE SALINE SOILS OF THE DELHI STATE

I.—SOME TYPICAL PROFILES OF THE JUMNA *KHADAR* AREA (NORTH)

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THE Jumna *khadar* (new alluvium) area of Delhi State in which a reconnaissance soil survey was conducted, is one of the four natural divisions of the State. Lying as it does, it is a strip of the land bounded by the river Jumna on the East, the grand trunk road on the West, the N. C. A. Civil Lines on the South, and the State boundary on the North. It covers an area of 45,139 acres of which only 48 per cent is under cultivation, the rest remaining as cultural waste and land unfit for cultivation. In these areas soil salinity is a factor which either mitigates crop yields or totally prohibits crop growth. This reconnaissance soil survey has, therefore, for its first object an examination of the saline and non-saline soils of the area to find out the possibilities of amelioration of the saline soils. Secondly, the nature and properties of the soils have been studied in detail to determine their origin and place in the world groups.

Material and methods

Three soil profiles, representing areas of different degrees of salinity, so as to cover the full range of the problem, at the Escort's Agricultural Farm and a fourth representative of the cultivated area from the Jumna Tractor Cultivation Farm, in the village Burari were examined. The profile description as recorded in the field is given in Appendix I. The profiles were characterised by the absence of horizon differentiation and structural formations. However, textural variations with the depth of the profile formed the basis of differentiation. Composite soil sample for each of the textural classes were drawn for an examination of their properties in the laboratory. Further, the underground water of the profiles was taken for analysis of its salt composition. To achieve the objects enunciated, the physical, chemical, physico-chemical and mineralogical properties of the soils were studied in the laboratory employing the following methods.

Analytical methods employed :

1. Mechanical analysis	International Method A. [1929].
2. Water soluble ions	Piper's method [1947]. The proximate composition of the salts was worked out by a combination of the acids and bases available after the method of Leather [1902].
3. Total cation exchange capacity and exchangeable cations	Neutral ammonium acetate method of Schollenberger [1930]. Necessary corrections were made for the water soluble fraction.

4. Soil reaction	Glass electrode (Cambridge *p*H meter) using 1 : 2·5 soil suspension in CO_2 free distilled water. Wright [1939].
5. Water holding capacity	Keen-Raczkowski box method using soil passing through 1 mm. sieve. Keen-Raczkowski [1921].
6. Moisture equivalent	Briggs-Mclane centrifugal method. Wright [1939].
7. Sticky point	Keen and Coutts [1928].
8. Permeability	Standard permeameter using the technique of Fireman [1944].
9. Dispersion coefficient	Puri's method [1930].
10. HCl extract	According to A. E. A. method [1931]· P_2O_5—Volumetric method A.O.A.C. [1940]. K_2O—Volumetric cobaltinitrite method—Piper [1947].
11. Organic carbon	Rapid titration method of Walkley and Black [1934].
12. Nitrogen (total)	Kjeldah's method with Bal's [1925] modification.
13. Loss on ignition	A. O. A. C. [1940].
14. Carbonates	By liberation of CO_2 with dilute HCl and absorbing the same in standard baryta. Laboratory method (I.A. R.I.).
15. Fusion analysis	Piper's method [1947].
16. Mineralogical analysis	By the use of Bromoform following the method of Jeffries [1941].

Experimental results

(i) *Mechanical analysis.* From the results of mechanical analysis presented in Table I, it is seen that the general character of the four profiles is a decrease in the clay content with depth—the degree of variation being different for each of the profiles. In the case of profile III, though there is a decrease in clay with depth, this decrease is very small in magnitude. The presence of lime concretions at the third foot in profile II and a deep bed of sand at 13 inches depth in profile IV are features of special interest. The depth of the profile in each case is conditioned by the water table which is very high, the range being 36 to 66 inches.

TABLE I

Results of mechanical analysis (oven dry basis)

Profile number	Depth in inches	Clay per cent	Silt per cent	Fine sand per cent	Coarse sand per cent
I	0—2	50·54	31·79	11·00	0·58
	2—9	46·45	28·05	22·45	1·79
	9—18	36·67	27·02	30·74	5·91
	18—27	33·70	27·29	27·55	10·72
	27—48	13·50	16·99	44·01	26·08
	48—63	7·10	2·93	8·43	79·75
II	0—9	39·23	19·72	37·41	1·17
	9—18	27·30	19·48	46·67	7·15
	18—27	21·56	17·96	43·00	13·39
	27—36	13·78	13·05	54·92	14·34
III	0—12	28·84	29·49	33·18	1·10
	12—44	25·69	55·37	17·42	0·16
	44—66	26·46	26·09	39·90	2·78
IV	0—8	23·02	41·43	23·94	6·35
	8—13	13·72	32·01	27·92	19·14
	13—48	1·86	3·22	17·46	77·80

(ii) *Water soluble salts.* The analytical results of the soil water extracts for total solids, sodium chloride and sodium sulphate as a percentage of the total solids and the *p*H of the soil water extract, are included in Table II. The results show that in respect of depth distribution, the water soluble salts decreased with depth in profiles I, III and IV but the concentration for any given depth is of a higher order in profile III than in the rest. The variation in profile II is narrow and can be regarded as fairly uniform throughout. Profile IV is distinctly characterised by a very low percentage of soluble salts. The salinity is outstandingly one of sodium salts viz., sodium chloride and sodium sulphate. Sodium carbonate is particularly absent. All the water extracts showed an alkaline reaction and in all the profiles examined an increase in *p*H with depth is observed. The surface layer of

profile II, is however an exception in this regard. The underground water of profiles I, II and III registered a markedly higher percentage of total water soluble salts than the soil water extracts corresponding to the respective profiles ; however, the nature of the salts remained more or less the same.

TABLE II

Water soluble salts of soil water extracts and underground waters

Profile number	Depth in inches	Total water soluble salts per cent	As a per cent of total solids		
			NaCl	Na_2SO_4	*p*H
I	0—2	1·24	46·55	..	8·07
	2—9	0·30	51·93	..	8·15
	9—18	0·26	59·50	..	8·20
	18—27	0·22	60·17	..	8·35
	27—48	0·23	50·71	..	8·60
	48—63	0·18	48·05	..	8·54
	U.G.W.	1·29	49·62	..	8·53
II	0—9	0·30	36·80	28·91	8·80
	9—18	0·47	36·47	25·74	8·16
	18—27	0·33	32·05	27·66	8·25
	27—36	0·32	63·80	22·02	8·40
	U.G.W.	1·14	61·39	..	9·06
III	0—12	1·66	52·80	..	8·14
	12—44	0·91	69·65	..	8·23
	44—66	0·57	70·86	12·03	8·45
	U.G.W.	2·28	56·35	..	8·52
IV	0—8	0·08	5·16	..	8·36
	8—13	0·05	8·14	..	8·63
	13—48	0·02	..	..	8·71

U.G.W.—means under ground water

(iii) *Total cation exchange capacity and exchangeable cations.* The results on total cation exchange capacity, exchangeable cations and the *p*H of the soils embodied in Table III warrant the following. The cation exchange capacity decreases with depth thus closely following the clay content. Although very distinct indications are apparent that the divalent cations Ca^{++} and Mg^{++} are moving down the profile while the monovalent ones, Na^{+} and K^{+} is in the reverse order. The *p*H of the soils are on the alkaline side of neutrality and increase with depth.

TABLE III

Cation exchange capacity and exchangeable cations (in milli equivalents per 100 gm. of oven dry soil)

Profile number	Depth in inches	Total C.E.C.	Exchangeable cations				*p*H
			Ca	Mg	K	Na	
I	0—2	18·13	12·00 (66·18)	3·83 (21·13)	0·81 (4·46)	1·49 (8·22)	7·87
	2—9	15·10	7·86 (51·83)	3·24 (21·45)	0·91 (6·22)	3·09 (20·46)	8·20
	9—18	12·34	6·11 (49·50)	2·72 (22·05)	0·77 (6·24)	2·74 (22·21)	8·33
	18—27	12·00	4·74 (38·99)	2·64 (22·51)	0·65 (5·42)	3·97 (33·09)	8·38
	27—48	5·83	2·31 (41·34)	1·48 (25·39)	0·38 (4·80)	1·66 (28·47)	8·40
II	0—9	13·87	9·60 (69·20)	2·16 (15·57)	0·59 (4·25)	1·52 (10·95)	8·72
	9—18	15·55	11·18 (71·88)	2·45 (16·09)	0·74 (4·75)	1·18 (7·59)	8·51
	18—27	7·35	3·76 (51·11)	1·91 (25·98)	0·34 (4·62)	1·34 (18·23)	8·99
	27—36	6·06	1·00 (16·50)	1·50 (24·75)	0·26 (4·30)	3·30 (54·45)	8·96
III	0—12	12·48	6·09 (48·79)	2·32 (18·59)	0·54 (4·32)	3·53 (28·29)	8·18
	12—44	10·14	5·95 (58·68)	2·12 (20·90)	0·46 (4·53)	1·61 (15·88)	8·58
	44—66	8·29	4·18 (50·42)	1·92 (23·16)	0·43 (5·18)	1·76 (21·22)	8·68

C. E. C.—means cation exchange capacity. Figures in brackets represent the percentage saturation with the cation in each case. Calcium is determined by difference.

(iv) *Physical properties.* The physical properties determined include, water holding capacity, moisture equivalent, sticky point, permeability and dispersion coefficient. Of these the dispersion coefficient was determined both initially and after washing the soils with water. The results are given in Table IV. The value for water holding capacity decreases with depth as does the clay content. The results of moisture equivalent showed a positive correlation with the clay content and the fine fractions (clay plus silt). The values for sticky point are similar in their trends to those of moisture equivalent. The rate of permeability increases with depth in all the profiles except the III, where it is at a minimum in the middle layer. Except in the case of profile No. I, an inverse relationship is obtained between the rate of permeability and suspension per cent of the sample. In the case of profile No. I, of course, the relationship between the samples at the top (surface) and the lowest horizon is quite characteristic. The values for dispersion coefficient are low initially but increased enormously after the removal of the salts by washing. They however, remained the same in the case of profile IV, where the salt per cent is very low.

TABLE IV

Physical properties of soils

Profile Number	Depth in inches	Water holding capacity	Moisture Equivalent	Sticky point	Dispersion Initial	Coefficient after washing	Permeability*	Suspension per cent†
I	0—2	58·59	44·88	42·92	16·94	58·66	0·030	41·04
	2—9	35·41	31·61	31·79	8·81	49·00	0·017	17·86
	9—18	35·69	26·63	32·43	10·02	79·45	0·025	17·01
	18—27	35·18	21·32	27·72	8·14	91·14	0·084	17·12
	27—48	33·36	14·07	19·60	16·15	66·04	0·392	11·04
II	0—9	38·53	28·31	26·42	19·12	73·02	0·005	23·64
	9—18	38·14	23·93	21·81	20·46	55·81	0·018	20·19
	18—27	34·66	22·29	22·23	23·81	62·63	0·034	17·17
	27—36	38·72	20·66	22·62	21·64	33·37	0·092	12·95
III	0—12	47·61	28·14	25·71	10·75	48·01	0·083	23·64
	12—44	42·28	30·98	39·44	12·28	27·96	0·016	30·97
	44—66	36·11	25·40	23·67	12·40	44·92	0·090	23·23
IV	0—8	43·16	27·49	24·79	29·24	31·34	0·055	29·82
	8—13	39·60	21·34	20·65	31·34	31·25	0·123	21·94
	13—48	22·03	3·31	..	..	..	..	..

* The rate of permeability is expressed as cubic inches per hour per unit of 1 sq. inch area through a saturated soil column under a constant water head of 4 inches of water.

† Suspension per cent is determined according to the method of Middleton [1931].

(v) *Chemical properties.* Such of the chemical properties that would be of help in an understanding of the nature of the soils under study, and their fertility level, were studied. They included a determination of carbonates, organic carbon, organic nitrogen, total phosphoric acid and potash. Clay composition was studied through a fusion analysis. The results are presented in Table V. The percentage of carbonates showed an increase with depth in profiles II and III, while in others it is uniform. The soils, in general, can be regarded as calcareous. The soils are low in organic matter and a majority of it is concentrated in the surface layer itself. The surface layers of the profiles are fairly rich in mineral nutrients, total P_2O_5 and K_2O as shown in Table V(*a*).

TABLE V

Chemical properties of soils (results expressed on oven dry basis)

Depth in inches	Loss on ignition	$CaCO_3$ per cent	Organic carbon per cent	Organic nitrogen per cent	C/N ratio
Profile I					
0—2	8·30	0·67	1·751	0·203	8·62
2—9	4·68	0·68	0·696	0·128	5·44
9—18	4·51	0·59	0·375	0·072	5·21
18—27	3·55	0·60	0·240	0·068	3·53
27—48	2·18	0·66	0·134	0·040	3·35
Profile II					
0—9	3·56	0·03	0·282	0·083	3·39
9—18	2·69	0·03	0·146	0·054	2·70
18—27	2·89	0·72	0·136	0·042	3·24
27—48	2·23	2·05	0·081	0·036	2·25
Profile III					
0—12	3·60	0·64	0·205	0·055	3·73
12—44	5·49	1·31	0·135	0·063	2·14
44—66	3·54	2·16	0·113	0·043	2·63
Profile IV					
0—9	2·07	2·41	0·594	0·094	6·32
	2·08	2·14	0·433	0·064	6·76

TABLE V(*a*)

Fertility level of surface soils

Profile number	Depth in inches	Total P_2O_5 per cent	Total K_2O per cent
I	0— 9	0·167	0·604
II	0— 9	0·084	0·587
III	0—12	0·126	0·495
IV	0— 8	0·132	0·524

The results of fusion analysis presented in Table V(*b*) of clays isolated from the soil samples of profile IV, show that there is an increase in silica sesquioxide and silica alumina ratio with depth indicating downward leaching of the silica and its deposition in the lower layers.

TABLE V(*b*)

Fusion analysis of clays

Depth in inches	0—8	8—13
Moisture per cent	3·85	4·22
Loss on ignition at 850°C	9·83	10·10
H. F. Residue per cent	0·89	1·02
SiO_2 per cent	44·93	46·88
Fe_2O_3 per cent	9·82	10·69
Al_2O_3 per cent	27·22	26·13
Derived data :		
SiO_2/R_2O_3 (molar)	2·27	2·39
SiO_2/Al_2O_3 (molar)	2·79	3·02
Al_2O_3/Fe_2O_3 (molar)	4·34	3·84

(vi) *Mineralogical studies.* The fine and coarse sand fractions obtained in the course of mechanical analysis were taken and separated into heavy and light fractions using Bromoform Sp. gr. 2·875, following the method of Jeffries [1941]. The fractions were mounted on microscopic slides with canadabalsam following essentially the procedure described by Milner [1936]. The slides were examined under a petrological microscope and the minerals were identified. A quantitative estimation of the

minerals made, is presented in Table VI. The percentage of heavy fraction in the soil varies between 0·25 and 0·68 and in depth distribution it is irregular. The mineralogical make up of the heavy fraction revealed the presence of both resistant and non-resistant minerals. As regards individual minerals, in the heavy fraction of the fine sand biotite and muscovite are present and in the light fraction the potash felspars are present in large amounts. Apatite is present in small quantities. Hornblende and garnet are the only lime-bearing minerals noted.

TABLE VI

Mineralogical analysis (profile I) of heavy fraction

Depth in inches	Fine sand			Coarse sand
	0—2	9—18	18—63	48—63
Heavy fraction per cent	2·3	2·2	0·76	1·14
Heavy fraction per cent in the soil	0·25	0·68	0·06	..
Minerals as per centage				
Biotite	11	17	23	24
Muscovite	12	20	19	17
Hornblende	35	23	15	18
Garnet	5	10	9	19
Apatite	—	—	2	—
Epidote	7	7	8	Traces
Tourmaline	2·5	2	1	1

DISCUSSION

Delhi State in which lies the area under survey, with Lang's rain factor 27·3 and Meyer's N. S. Quotient 123·6 is admittedly under the influence of arid climate. The general soil characteristics such as low values of organic matter and clay and saline nature are the probable characteristics imprinted by this arid climate [Jenny, 1941].

Of the four profiles under study, the three belonging to the Escort's Agricultural Farm, represent different grades of salinity and the fourth of a non-saline cultivated area. The profile depth for morphological description is conditioned by the water table which varied from 36 in. to 66 in. and under the influence of such a high water table in an arid region, the development of salinity in the soils occasions no surprise. As the tract is often flooded by river Jumna and is also in close proximity to the river, high water table is found in this farm. Saline soils without high water table could not be found amongst the profiles studied.

The morphological features of the soils are in general agreement with those reported by Basu [1937] and Puri [1949] for saline soils. The absence of horizon differentiation and structural formation coupled with a decrease in the salt content with depth of the profile (without zones of salt concentration) all suggest that these soils belong to the group of *solonchak* soils.

The salinity of the soils is outstandingly one of chlorides and, therefore, falls under the fourth group of salinity classification according to Kovda [1946] and this again is evidently due to the prevalence of an arid climate. The origin of the salts in the profile could possibly be traced to the upward movement of underground water, whose salt composition is more or less similar to that of the soil water extracts, but of a markedly higher magnitude.

The soils are base saturated and the irregularities of the cation composition of the exchange complex with the depth of the profile must be attributed to the limitations of the method of their estimation as pointed out by Richards [1947]. Further the probable disturbance in equilibrium conditions caused by the frequent flooding of the area by the river Jumna in close proximity cannot be excluded. The percentage of sodium in the exchange complex of the soils under study varies between the maximum values of Kelly [1937] for white alkali soils and minimum values of the black alkali. The development of marked solonetz characters consequent on high sodium saturation must probably have been reduced due to the arid climate according to Antipov-kartaev and Sedletskii [1937]. The soils can, therefore, be regarded to be in a high stage of salinisation with slight tendencies toward alkalisation.

The reaction of all the soils is on the alkaline side of neutrality but below 9·0. The values, as they are, are important in as much as they are an excellent index of the stage of salinisation which according to Joffee [1949] whenever the *p*H is not above 8·2 to 8·4 the *solonchak* has, as a rule no sodium carbonate and the soil is probably in the stage of progressive salinisation. Only with the appearance of sodium carbonate does the *p*H go up and such soils are in the stage of desalinisation.

That the initial low dispersability of the soils is due to the presence of the salts acting as electrolytes is apparent from the fact that salt removal, by washing with water, increased enormously their dispersability. The high values of dispersion coefficient of the washed soils are in agreement with the observations of Puri [1930] and are characteristic of the saline and alkaline soils. Increase in permeability with depth is more due to the decreasing heaviness in texture which observation falls in a line with that of Fireman [1944] and Pillsbury and Appleman [1945] that texture rather than structure dominates in determining soil permeability in arid soils. The inverse relationship between the rate of permeability and the silt and suspension percentages of the soils confirms the observations of Salter and Byres [1931].

Mineralogical studies revealed that the distribution of heavy fraction of fine and coarse sand in the soil profile is irregular and cannot, therefore, indicate any stage of soil maturity. The mineralogical make up of the heavy fraction showed the presence of both resistant and non-resistant mineral groups but their depth distribution in the profile is highly erratic.

In respect of amelioration of these soils, the studies made indicate that improvement of drainage conditions is the first step to be followed up by a slow washing out of the salts with water of good quality. The soils being calcareous, the use of gypsum may not be of great use. The next choice would be sulphur. At the same time salt tolerant crops like paddy, barley and berseem may be tried. In the low lying areas paddy may be preferred to other crops. The profile studies thus indicate the choice of appropriate reclamation methods for areas exhibiting different degrees of salinity. These are either simple cultural methods like drainage practised alone or along with the application of soil amendments like sulphur.

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APPENDIX I

Profile descriptions

Profile I (Good area of the farm.)

Location Escort's Agricultural Farm, Delhi State.

Topography—Level area.

Rainfall—25 inches.

Drainage—Fair.

Vegetation—Grasses and shrubs.

Past and present use—Uncultivated, intended for cultivation.

Depth in inches	*Morphological description*
0—2	Grey, clays, crumby structure, roots densely spread throughout. Compact and dry, very slight reaction to dilute HCl.
2—9	Grey, clays, compact, structureless, roots in large numbers, dry, slight reaction to dilute HCl.
9—18	Grey, clays, yellow mottlings, few thick roots, very moist, slight reaction to dilute HCl.
18—27	Brown, clay, brown and yellow mottlings are conspicuous, soft and brown accumulations of iron are noticed, very few roots, moist, slight reaction to dilute HCl.
27—48	Brown, sandy loam, structures undeveloped, few thin roots, very wet, fair reaction to dilute HCl.
48—63	Grey, sandy, very wet, fair reaction to dilute HCl, water table below 63 inches.

Profile II (Land of medium productiveness of the farm.)

Location—Escort's Agricultural Farm, Delhi State.

Topography—Low lying area.

Rainfall—25 inches.

Drainage—Moderate.

Vegetation—Sparse.

Present and past use—Area lying waste and opened up recently for cropping.

Depth in inches	*Morphological description*
0—9	Greyish brown, clays, structure undeveloped, not compact but loose, no reaction to dilute HCl, fine roots densely spread out, mottlings of iron in blotches are conspicuous, the layer is moist.
9—18	Grey, clay loam, undeveloped structure, slight reaction to dilute HCl, roots are few but thick, the layer is fairly moist, mottling of iron throughout in the form of spots and slaty coloured patches.
18—27	Grey, clay loam, few thick roots, wet throughout, vigorous reaction to dilute HCl.
27—36	Grey, sandy loam and moderately compact, mollusc shells of small size found in large numbers, very wet throughout, a band of lime concretions is noted. Water table below 36 inches.

Profile III

(Barren and salt encrusted area of the farm).
Location—Escort's Agricultural Farm, Delhi State.
Topography—Level land.
Rainfall—25 inches.
Drainage—Poor.
Vegetation—Totally absent.
Present use—Intended for reclamation.

Depth in inches	*Morphological description*
0—12	Grey brown, clay loam, friable, massive, few roots, moist, slight reaction to dilute HCl.
12—44	Lighter in colour than the above, clay loam, massive, no roots, very moist throughout, reaction to dilute HCl is vigorous.
44—66	Darker in colour than the above and similar to the top layer of 0—12 in. Clay loam, no roots, wet and the water table is met with at 66 in. depth.

Profile IV

(Area under cultivation).
Location—Jumna Tractor Cultivation Farm, Burari, Delhi State.
Topography—Level land.
Rainfall—25 inches.
Drainage—Fair.
Vegetation—Very rich, trees, shrubs and grasses are present in the neighbourhood.

Depth in inches	*Morphological description*
0—8	Loose top layer particularly due to tractor ploughing, light grey, clay loam, the entire zone is densely ramified with fine roots, moderate reaction to dilute HCl, reaction mildly alkaline.
8—13	Yellowish brown, silt loam, compact, structure pyliform, fine root hairs in small numbers, reaction to dilute HCl is slight, brown motttling spots ; moderately moist throughout ; reaction mildly alkaline.
13—48	Grey, sandy, loose soil.

CHEMICAL FERTILIZERS AND SOIL PRODUCTIVITY

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IN Indian soils, the soil fertility has been stabilized at a low level as will be evident from the results of many experiments and crop cutting surveys in different parts of the country, although some of these experiments and also the yields obtained by efficient farmers show that the potential crop yielding capacities of our soils under our climatic conditions are often good and quite encouraging. Higher crop yields lead to greater exhaustion of the soil and in intensive farming it is the practice all over the world to use heavy application of fertilizers or manures.

While the bulky organic manures have been in use in various countries as far back as the agricultural records go, the introduction of inorganic concentrates in the form of artificial fertilizers for augmenting crop production is comparatively recent. About 4·2 million tons of nitrogen, 2·1 million tons of phosphoric acid, 7·3 million tons of potash and 4·8 million tons of lime are removed annually from the soil by the various crops. To maintain soil productivity and to improve crop yields it is necessary not only to replenish these amounts but also to add more, as a part of the plant nutrients added to the soil are likely to be lost by leaching or other causes or are rendered unavailable or slowly available to the plants.

The use of artificial fertilizers has been subjected to the criticism of being harmful to the physical and chemical conditions of the soil. Experimental evidence, however, shows that the use of well balanced fertilizers has given good results comparable to those obtained by the application of heavy doses of bulky organic manures. Moreover, the ratio of plant nutrients can be correctly regulated by use of artificials, whereas the amounts of such nutrients are fixed in organic manures and cannot be altered and this may result in unbalanced manuring of the crop. Chemical fertilizers like sulphate of ammonia, superphosphate and sulphate of potash have been compared with bulky organic manures in a number of long term permanent manurial and rotational experiments at Pusa, Kanpur and Coimbatore and quite high and comparable yields have been obtained by the use of balanced mixtures of inorganic fertilizers containing nitrogen, phosphoric acid and potash, as will be evident from the following tables.

Though organic manures especially bulky organics contain large amount of carbonaceous waste matter which goes a long way in meeting the acute shortage of humus in the tropical soils of India yet the percentage of plant nutrients present are rather low to meet the full demands of healthy crops. For example, farm yard manure is one of the most important organic manures used in India, on an average it contains about 0·5 per cent N and 0·3 per cent P_2O_5 on dry basis, which means that for an adequate supply of N or P a very large bulk of it must be used which can only be possible provided sufficient amount of alternative fuel is made available at

TABLE I

Five to ten years experiments—Paddy

Place	Control yield in lb. per acre	Inorganic		Organic		Inorganic+ organic	
		Rate	Per cent increase over control	Rate	Per cent increase over control	Rate	Per cent increase over control
1. Khasi and Jaintia Hills (1925-30), Assam	2,103	Sodium Nitrate 17 lb. N Bone meal 10 lb. N and 55 lb. P_2O_5.	15·3 75·0	..	..	..	..
2. Karjat, Bombay (1925-29)	2,680	Ammonium Sulphate 60 lb. N.	36	..	..	..	..
3. Coimbatore, Madras (1925-31)	2,540	Sodium Nitrate 50 lb. N	9	Cattle manure 50 lb. N.	13	G. M. 30 lb. N+ Sodium Nitrate 20 lb. N	21
				G. M. 50 lb. N	21	G. M. 20 lb. N+ Sodium Nitrate 30 lb. N. Cattle manure 30 lb. N+ Sodium Nitrate 20 lb. N. Cattle manure 20 lb. + Sodium Nitrate 30 lb. N	20·4 15 15
4. Manganallur, Madras (1916-21) (1915-22)	1,900 1,170	Ammonium Sulphate 67 lb. N.	15	Green leaf 20 lb. N.	24	..	..
5. Raipur (M. P.) (1939-43)	988	Ammonium Sulphate 20 lb. N.	52	..	..	..	..
		Super 20 lb. P_2O_5	39	..	..	..	..

TABLE I—*contd.*

Five to ten years experiments—Paddy—contd.

Place	Control yield in lb. per acre	Inorganic		Organic		Inorganic + organic	
		Rate	Per cent increase over control	Rate	Per cent increase over control	Rate	Per cent increase over control
		Ammonium Sulphate + Super 20 lb. N + 20 lb. P_2O_5.	115	..	..	..	..
6. Labhandi (M. P.) (1939-43)	1,158	Ammonium Sulphate 10 lb. N.	31	..	..	..	..
		Super 10 lb. P_2O_5	17	..	..	..	..
7. Chinsurah (W. B.) (1936-41)	2,061	Ammonium Sulphate + Super 10 lb. N + 10 lb. P_2O_5.	60	..	..	..	..
		Niciphos 20 lb. N + 20 lb. P_2O_5.	22	..	..	..	..
		Ammonium Sulphate + Super 20 lb. N + 20 lb. P_2O_5.	22	..	..	..	..

TABLE II

Five to ten years Experiments—Wheat

Place	Control yield in lb. per acre	Inorganic		Organic		Inorganic+ organic	
		Rate	Per cent increase over control	Rate	Per cent increase over control	Rate	Per cent increase over control
1. Pusa (Bihar) (1933-49)	241	Ammonium Sulphate 20 lb. N.	7·1	Rape cake 20 lb. N	93·4	G. M.+ Super 40 lb. P_2O_5.	427
		Ammonium Sulphate 20 lb. N+ Super 40 lb. P_2O_5.	138	F. Y. M. 40 lb. N .	249		
		Super 40 lb. P_2O_5 . .	93·4	F. Y. M. 20 lb. N .	141		
		Potassium Sulphate 25 lb. K_2O.	8·0	G. M. Sunhemp .	106		
		N+ P+ K . . .	147·0				
2. Chindwara (Madhya Pradesh) (1935-40)	760	Ammonium Sulphate 20 lb. N.	13·1	Karanj cake 20 lb. N	22·3		
		Niciphos 20 lb. N+ 20 lb. P_2O_5.	16·9	F. Y. M. 10 cart loads.	30·6		
3. Powerkhera (Madhya Pradesh) (1940-45)	392	Ammonium Sulphate 10 lb. N.	27·7				
		Ammonium Sulphate 15 lb. N.	20·9				
		Niciphos 10 lb. N + 10 lb. P_2O_5.	30·9				
		Niciphos 15 lb. N + 15 lb. P_2O_5.	48·9				
4. Kanpur (Uttar Pradesh) (1882-86)	804	Ammonium Chloride 30 lb. N+ Super 32 lb. P_2O_5+ Calcium Sulphate.	97				

competitive prices. Moreover only half of this nitrogen, one sixth of P_2O_5 and a little over one half of K_2O are readily available to plants. On this basis one ton of the manure supplies only 5 lb. of nitrogen to the crop, and the phosphoric acid content is too low to be fully effective. In view of the fact that organic manures tend towards improving soil structure and the humus content of the soil so very useful for the development of soil microflora their application to the soil is always welcome addition. The shortage of the amount of plant nutrients can be easily regulated with the help of chemical fertilizers. A combination of farm yard manure or compost or green manure along with superphosphate, etc. has in general been found to maintain soil productivity at an excellent level. Relevant example may be cited from the results of the Pusa Permanent Manurial Experiments in North Bihar where the soil organic matter gets readily oxidised in the light calcareous soil. Six tons of farm yard manure has on an average indicated about 150 per cent rise in yield over no manure, whereas the application of sannhemp green manure with superphosphate has given over 400 per cent rise. Not only at Pusa but practically at every centre proper mixture of an artificial with bulky organics has given very good results for long periods of experimentation. In sugarcane manuring too it has been observed in general that when farmyard manure has been supplemented by sulphate of ammonia significantly higher yields were obtained over farm yard manure alone. Similar trends have been seen in trials with wheat at various other centres for long term trials, as will be evident from Table III.

There is a school of thought which believes that though the crop yield may rise with the application of inorganic fertilizers yet the quality of the crop and its nutritional values may not be of a very high order. Table IV shows that in Pusa Permanent Manurial trials the wheat crop grown with inorganic fertilizers are as good as those grown with organic manures.

A point cited against the widespread use of chemical fertilizers for the maintenance of soil productivity, is that the continued use of fertilizers in course of time is likely to deplete the soil of other plant nutrients so that the successive crop production is substantially lower. The fact cannot be ruled out outright. Vigorous crop growth does exhaust the soil rapidly but the defect can be remedied by the application of food elements which are essential for the maintenance of the balance of the plant nutrients in the soil for successful crop production. Examples have been cited of trials conducted for fairly long periods where suitable fertilizers have been used in correct proportions to produce high crop yields and there is no immediate evidence of soil deterioration. For example, at Woburn experimental station continuous application of sulphate of ammonia for 50 years has resulted in almost complete failure of crops due to the development of acidity, while the application of lime has been successful in restoring soil productivity to normal.

Average yield of crops in India by the application of chemical fertilizers in relation to soil types

Indian soils in general lack in their nitrogen content and the response to nitrogenous fertilizers is practically universal. No doubt exists amongst the agriculturists regarding the improvement of yield by the application of ammonium sulphate and

TABLE III

Long term experimental results about 10 years duration and above—Wheat

Place	Control yield in lb. per acre	Cakes		Cattle dung		G.M.		Organic and inorganic	
		Rate	Per cent increase over control	Rate	Per cent increase over control	Rate	Per cent increase over control	Rate	Per cent increase over control
1. Powerkhera(Madhya Pradesh) (1931-49) Dry	302	..	..	40 lb. N	42	..	..	..	..
Powerkhera (Madhya Pradesh) (1919-30) Unirrigated	620	30 lb. N	25	40 lb. N	21	Not given	20	G. M. Sann + Super 164 lb.	20
2. Tharsa (Madhya Pradesh) (1940-49) Irrigated	477	25 lb. N	15	25 lb. N	4	..	..	Cattle dung 10 lb. N+ Niciphos 15 lb. N. Cattle dung 10 lb. N+ Amm. Sulph. 15 lb. N	26 15
3. Nagpur (1890-1901) Irrigated	420	..	..	..	..	Not given	36	..	..
4. (*a*) Kanpur (Uttar Pradesh) (1885-95) Irrigated	1096	..	..	80 lb. N	35	..	..	Cow dung 95 lb. N+ Bone dust 70 lb. P_2O_5.	36
(*b*) Kanpur (Uttar Pradesh) (1896-1913) Rotation wheat-maize	1285	..	..	100 lb. N	68	..	..	..	..
5. Chindwara (1921-30)	600	..	..	..	..	Not given	18	..	..
6. Pratapgarh (1916-30)	1170	..	..	..	..	„	16·5	..	..

TABLE IV

Analysis of wheat from Old Manurial Series B, Pusa, Bihar (1948-49)

Treatment	H_2O per cent	Ash per cent	CaO per cent	P_2O_5 per cent	Crude protein per cent N×5·7	Ether Extract per cent	Crude fibre per cent	Nicotinic acid M gm. per 100 gm.
1. F. Y. M. 8,000 lb. per acre	10·49	1·92	0·211	0·722	9·93	2·82	2·89	10·91
2. Rape cake 40 lb. N	10·70	1·68	0·215	0·763	12·83	1·86	2·83	11·79
3. K_2O 50 lb. per acre P_2O_5 80 lb. per acre	10·65	2·02	0·277	0·963	11·27	1·94	3·33	11·75
4. N. 40 lb. per acre P_2O_5 80 lb. per acre K_2O 50 lb. per acre	10·51	2·21	0·268	1·160	11·58	2·20	2·88	11·08
5. N. 40 lb. per acre P_2O_5 80 lb. per acre	11·04	2·12	0·200	1·082	10·65	2·72	2·74	11·76
6. Green manure with a purely cereal rotation	10·45	1·63	0·225	0·788	13·74	2·09	3·73	11·16
7. No manure	10·30	1·86	0·300	0·478	14·15	2·56	2·36	11·97
8. N. 40 lb. per acre K_2O 50 lb. per acre	9·58	1·58	0·243	0·594	14·55	2·37	2·39	7·96
9. Green manure in rotation	10·20	1·55	0·244	0·468	14·23	2·62	2·76	7·83
10. Green manure with 80 lb. P_2O_5 applied to it	9·92	2·18	0·254	0·898	11·04	2·45	2·76	11·66
11. No green manure No legume	10·70	1·95	0·270	0·270	12·52	2·59	2·71	13·22

generally in all the states there is a great demand for this fertilizer. Superphosphate has comparatively a limited demand because the response to its application is frequently not observable immediately. Recent experiments have shown that the hitherto practised method of broadcasting of this fertilizer, has little value, and it is suggested that modern placement methods should be resorted to, to get the maximum benefits of phosphatic fertilization. The total and available potash status in Indian soils is fairly high and usually significant responses have not been obtained with potash in various manurial trials conducted during the past. However its use is recommended wherever necessary for balanced manuring especially with heavy doses of N and P where the uptake of potash by the crops like chillies, tobacco, jute, etc. from the soil may increase to such an extent as to induce potash deficiency.

In order to consider the crop responses under different fertilization schedules it is evident that the responses will vary according to the soil type, climatic and other agronomic factors and therefore only very general conclusions can be drawn from the existing limited experimental data.

Paddy. In alluvial soils the maximum percentage increase in paddy yields was obtained with the combination of artificial nitrogenous and phosphatic fertilizer (107·8 per cent increase over control) the response per lb. of nitrogen added being as high as 28·3 lb. of paddy. Nitrogen and phosphate alone were almost equal in effect on the yields (21·3 per cent and 22·6 per cent over no manure respectively). The effect of bulky organic manures on the yield was slightly less than those of N and P.

In laterite soils, however, bulky organic manures and oil cakes proved to be better than a mixture of organic plus inorganic the respective per cent increase over no manure, being 52, 64·4 and 37·8. The experiments with phosphate in these soils have been few and in general the increase in yields due to phosphate alone and with inorganic N has been small.

In red soils too bulky organics gave good responses but N plus P proved to be superior to either N or P singly.

The percentage increase in yield with inorganic nitrogen in the form of chemical fertilizers on paddy has been the best in the laterite soils and is followed by black, alluvial and red soils. The response per lb. of N applied was maximum in black and red soils and is followed by laterite and alluvial soils. The average percentage increase and responses per lb. of N applied were as given in Table V.

TABLE V

Percentage increase in yield in different soil types

Soil types	Increase per cent	Response in lb. per lb. of N applied
(I) Laterite	33·6	13·2
(II) Black	27·0	17·5
(III) Alluvial	21·3	10·0
(IV) Red	18·9	16·6

Trials with P alone are rather few. In red soils at Pratapgarh in an experiment for 15 years with super at 6 lb. P_2O_5 per acre the average increase in yields of 46·2 per cent and a response of 80 lb. per lb. of P_2O_5 were obtained. The general response in alluvial soils was also fairly good with 22·6 per cent increase over control. The number of experiments in black and laterite soils have been very few and the general indications are that only 10 per cent increase in yields could be obtained by phosphate manuring.

The average increase in yield with N plus combination has been generally more than either of them singly in all except in laterite soils where response in N alone (34 per cent over control) appears to have been depressed by a combination of phosphate (12·3 per cent over control).

Wheat. Wheat crop has been mainly confined to red, black and alluvial soils, the unirrigated crop being mainly grown in black soils. Most of the irrigated trials on the other hand have been made in alluvial soils. In the case of irrigated wheat a combination of artificial N and P appeared to have given the best increase in yields (60·6 per cent over control). This is followed by the treatment organics plus inorganics with an average increase of 37 per cent over control. In black soils a combination of inorganic N and P gave the best increase in yields. Trials with unirrigated wheat have been very few and most of them have been made with organic manures (Table VI).

Sugarcane. In irrigated trials on black soils at Padegaon (Bombay) an average increase of as much as 255 per cent over control was obtained by treatment with organics plus inorganics. Inorganic N alone gave 117 per cent increase in yield over control. In red soils N and N plus P have given on an average of 25 per cent increase over control. In the alluvial soils, inorganic N has proved to be the best (average increase in yield 78 per cent over control) and is followed by N+P (50·2 per cent over control). The results of application of phosphate alone in alluvial soils indicate no beneficial effects. With unirrigated sugarcane, no experiments have been reported from black soil areas. In red soils N plus P artificials gave an increase of (P) over control and have been followed by N alone (28 per cent). Phosphate alone gave the least increase. In alluvial soils N plus P has given an average increase of 78 per cent and is followed by artificial N (54 per cent) (Table VII).

Necessity for diversion of limited available fertilizers for irrigated crops

For maximum response and benefit from the use of fertilizers, it is obviously necessary that after application to soil, the plant nutrients should be brought in a state of solution from which plants may easily assimilate them. This points to the necessity of application of water immediately after addition of fertilizers and at intervals thereafter. Results obtained by the use of fertilizers in different tracts show that the response in unirrigated tracts is uncertain and comparatively very much smaller than in irrigated tracts. This is well illustrated by the results obtained at Jalgaon where with a rainfall of 43 inches and over, there were responses of 27 and 38 lb. per lb. N to a small dose of 4 lb. nitrogen per acre ; but with a rainfall of 30 inches response to nitrogen dwindled to 3 lb. per lb. nitrogen. Stewart [1947] stresses upon this important aspect of the question in the following words : ' Another all-important factor determining the amount of nitrogenous or indeed of any manure

TABLE VI

Soil types and fertilizer responses

Percentage increase of yields over no manure—Wheat

	Irrigated						Unirrigated					
	N	P	N+P	Bulky organics	Oil cakes	Organic and inorganic	N	P	N+P	Bulky organics	Oil cakes	Organics and inorganics
1. Alluvial	22	..	61	22	..	37	..	..	..	159	71	427
2. Black	..	..	..	61	..	..	..	(Twenty to twenty-five)			..	83
3. Red	20	10	..	57	54	..	..	..	102	..	42	..

TABLE VII

Percentage increase of yields over no manure—Sugarcane

	Irrigated						Unirrigated					
	N	P	N+P	Bulky organics	Oil cakes	Organic and inorganic	N	P	N+P	Bulky organics	Oil cakes	Organics and inorganics
1. Alluvial	78	No beneficial effect	50	13	29	..	54	..	78	..	..	30
2. Black	117	..	..	..	..	255	..	..	..	..	..	..
3. Red	25	56	25	..	102	..	28	3	41	..	..	..

for all crops is whether the crop is to be grown under rain-fed or irrigated conditions. Where lack of water is a limiting factor in crop growth full response to the application of a manure cannot of course be expected. Indeed application of more than relatively light dressings of nitrogen or of other manures under conditions of water deficiency may have harmful effects and from past experimental work it appears fairly definite that the more fully the water requirements of the crop are met the greater is the response to be expected from a given dose of manure and greater can be the useful rate of application'.

These considerations suggest that the limited quantitites of fertilizers available for use in the country at present could be more fully utilized by meeting, in the first instance the requirements of tracts which have irrigation facilities. In the present emergency this would give an assured and substantial increase in yield under the optimum conditions necessary for fertilizer use.

Conclusion

In view of the countrywide shortage of food and the acute need to attain self sufficiency level all efforts must be diverted towards improving soil productivity. Indigenous sources of manures can hardly meet the immediate demands of the country. The fuel position can never allow all the animal wastes and plant residues to be returned to the soil. The demand can only be met by the widespread utilisation of concentrates in the form of chemical fertilizers. The example of Japan illustrates most strikingly for what can be achieved in this direction. Japan occupied in recent years the third place for the consumption of nitrogenous fertilizers and first place in the use of phosphoric acid and potash per unit area of arable land. The average yield of paddy in Japan is 2,000 lb. per acre as against the average yield of 775 lb. of paddy per acre in India. All the crop producing countries in the world are adopting the increasing use of fertilizers for raising the standard of crop production and in recent years the world consumption of fertilizers has increased enormously and roughly about 16 million tons of different types of fertilizers are in use.

No doubt, the common trend of the cultivator is usually to go towards the use of organics partly due to their indigenous source and partly due to age old familiarity but in view of the present agricultural development facing the country the widespread use of chemical fertilizers alone or in mixtures with other fertilizers or organic manures would give the optimum results both in long and short term planning for improving soil productivity and maintaining soil fertility. Every attempt should therefore be made not only to conserve and utilise indigenous resources but also to liberalise the use of chemical fertilizers in the country.

Summary

Soils in India are principally deficient in nitrogen and the value of nitrogenous fertilizers has been well established by results of past experimental work. Some tracts are deficient in phosphorous also. The mode of applications of phosphatic fertilizers adopted hitherto is fundamentally defective and needs to be changed

to placement methods to get the best results. With regard to potash, Indian soils are generally well provided.

The nature of soil is an important factor in governing the response of fertilizers to crop growth. For instance, for paddy, alluvial soils respond well to nitrogenous and phosphatic fertilizers. On lateritic soils, bulky organic manures and oil cakes have proved more useful.

Prejudices against extensive use of fertilizers have generally been shown to be unfounded. In both short and long term experiments, judicious use of fertilizers has been found to maintain yields at high level. This does not clash with the value of bulky organic manures which have their own role to play in the maintenance of soil fertility.

The present emergency warrants greater use of fertilizers as an aid to increase food production in the country and in view of inadequate available quantities of these, it would be desirable to direct their use on irrigated tracts in the first instance, on which with an assured water supply, the optimum response possible could be expected.

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SYSTEMATIC INVESTIGATION OF SOIL ORGANIC MATTER WITH PARTICULAR EMPHASIS ON THE SOIL HYDROLYSATES OF AGRA SOIL

I. PRELIMINARY ANALYSIS OF THE HYDROLYSABLE ORGANIC MATTER IN THE SOIL

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(With Four text-figures)

SOIL is a complex mixture of organic and inorganic substances which result from very complicated chemical changes under the physical and biological forces of nature. Much work has been done on soil organic matter by eminent workers in this field. [Vauqualin, 1797 ; Mclean, 1931 ; Waksman, 1926.]

It has been an established fact that the quality of soil is very much influenced by the most resistant and complicated organic substance, humus, which has so far tenaciously challenged the efforts of great researchers to elucidate its composition. Humus has been defined as a complex and resistant colloidal substance that develops synthetically at the original organic tissues which suffer enzymatic dissolution by various soil organisms. It is a natural body and is exceedingly variable and heterogeneous, yet it possesses properties that distinguish it sharply from other natural organic aggregates. The prevailing view is that it is an indefinite complex which is designated as ligno-proteinate because of the observed prominence of lignin in the synthetic process. To the colloidal nature of humus has been ascribed such properties of the soil as are responsible for its fertility status. Slowness of reactions which bring about very gradual changes of physical and chemical properties on which the supply of nutrients to the plant depends, are also ascribed to the colloidal state. The formation of minute growth promoting substances, base exchange property, moisture conservation and soil colour, have been considered to arise out of the changes suffered by the mysterious complex—humus.

Fractionation of humus has been attempted by extraction with an alkali [Page, 1930 ; Sircar and Esh, 1940]. The humus fractions-humin, humic acid, and hymatomelanic acid were isolated, but they led to no conclusive results about its composition. Waksman [1938] has considered humus as a whole in the form of a complex humus nucleus, and he calls it as a lignin-protein complex at last.

In the light of the prevailing view regarding the composition of humus, we thought of investigating systematically the inorganic and the organic components of the soil of the Botanical Garden of Agra College. Results of our preliminary study are being communicated through this paper. Agra, being near the desert

land of Rajasthan, is expected to produce a typical tropical soil on the extreme border of the plains of Uttar Pradesh.

It is necessary to identify the existence of inorganic compounds in the soil before starting a systematic investigation of the organic matter. To study the inorganic components, the sample of the soil was digested with concentrated HCl and standard methods were employed to find that it contains the following radicals [Knowles and Watkin] in the order given below :

$$SiO_2 > Al > Fe > Ca > Mg$$

Sodium was also found to be present by the flame test. Samples of the soil were collected from layers six inches deep according to the method advocated by previous authors [Piper, 1947].

To search for such organic matter in the soil as could be removed by solvent action, direct refluxations were tried in various organic solvents, such as chloroform, benzene, carbon tetrachloride, petroleum, ether and alcohol. After refluxing for six hours, the refluxed solvents were filtered and the solvents were distilled off ; the concentrated residual liquid left in the distilling flask was evaporated to dryness on watch glass. It was observed that the organic matter obtained after evaporation to dryness was too small to enable us to proceed with a systematic analysis to identify the residue. This part of the investigation was, therefore, left over for the present, and this will be taken up later on after the major components of the soil have been investigated.

The soil was estimated for the total organic matter by Black and Walkley's method, and the percentage of organic matter was obtained by multiplying the percentage carbon by the factor 1·724 [Piper, 1947]. Since carbon and nitrogen vary from season to season in the soil, we estimated several samples in the month of May and June, 1950. The figures are tabulated below :

Sample	Percentage of carbon	Percentage of total organic matter (per cent C×1·724)
I	0·618	1·065
II	0·648	1·117
III	0·588	1·014

The soil was further analysed for the inorganic constituents by such standard methods as have been recommended by Piper [1947], Knowles and Watkin [1947]. The results of analysis are given below :

Loss on ignition	5·100	per cent
SiO_2	84·196	,,
Al_2O_3	3·941	,,
Fe_2O_3	3·249	,,
CaO	1·55	,,
MgO	1·021	,,
TOTAL	99·057	,,

Short references of the estimations are as follows :

1. Loss on ignition was determined by heating the air-dried sample in a platinum crucible in a muffle furnace. [Knowles and Watkin, 1947.]

2. Silica was estimated by digestion with strong hydrochloric acid. [Knowles and Watkin, 1947.]

3. Fe_2O_3 and Al_2O_3 were estimated in the filtrate from (2) by boiling with concentrated nitric acid and precipitating with ammonia and followed by washing and ignition. [Knowles and Watkin, 1947.]

4. Fe_2O_3 was estimated by reducing the ferric in the filtrate from (2) by zinc and sulphuric acid, and titrating against O·I N $KMnO_4$ solution. [Knowles and Watkin.]

5. Aluminium was obtained by difference of (3) and (4).

6. Calcium was estimated in the filtrate from (3) gravimetrically in a muffle furnance as calcium oxide [Cumming and Kay, 1945] by quick weighing.

7. Mg. wax estimated as $Mg_2P_2O_7$ in the filtrate from (6) and its equivalent MgO was calculated.

The base-exchange capacity of the soil for calcium and magnesium was determined by Hissink's method [Piper, 1947]. The soil was leached with normal sodium chloride solution and the leachate was collected separately in two flasks of capacity 1-litre each. The difference between the amounts of calcium in the first and the second flasks gave the exchangeable calcium of the soil. Magnesium was determined in the filtrate from the calcium precipitate, as Magnesium pyrophosphate. The results are given below ;

Exchangeable calcium—12·50 m.e. per 100 gm. of soil.

Exchangeable magnesium—8·53 m.e. per 100 gm. of soil.

Total exchangeable calcium and magnesium—21·03 m.e. per 100 gm. of soil.

Behaviour of the soil sample with HCl and H_2SO_4 at different concentrations

About 1,000 gm. of soil dried at 105° C. were refluxed with HCl and H_2SO_4 of various strengths for six hours. After six hours' heating, the solution in each case was filtered and evaporated to dryness. The residues left after evaporation were extracted with alcohol, filtered and collected in petri-dishes previously weighed. The alcohol was evaporated in an electrically heated air-oven at a temperature range of 100-105° C. and the dried mass was weighed several times, till the weight was practically constant. It may be noted here that the soluble and the insoluble organic matter in the alcohol was associated partly with inorganic salts also, mainly with calcium and sodium which make the mass hygroscopic if the weighing is delayed. In the same way, the alcohol insoluble portion was also dried in the oven and quickly weighed several times, till the weight was practically constant. By plotting the weights of this organic matter, soluble as well insoluble in alcohol, against the concentrations of the acid used, straight lines were obtained up to a certain limit of the concentration of HCl and H_2SO_4 respectively.

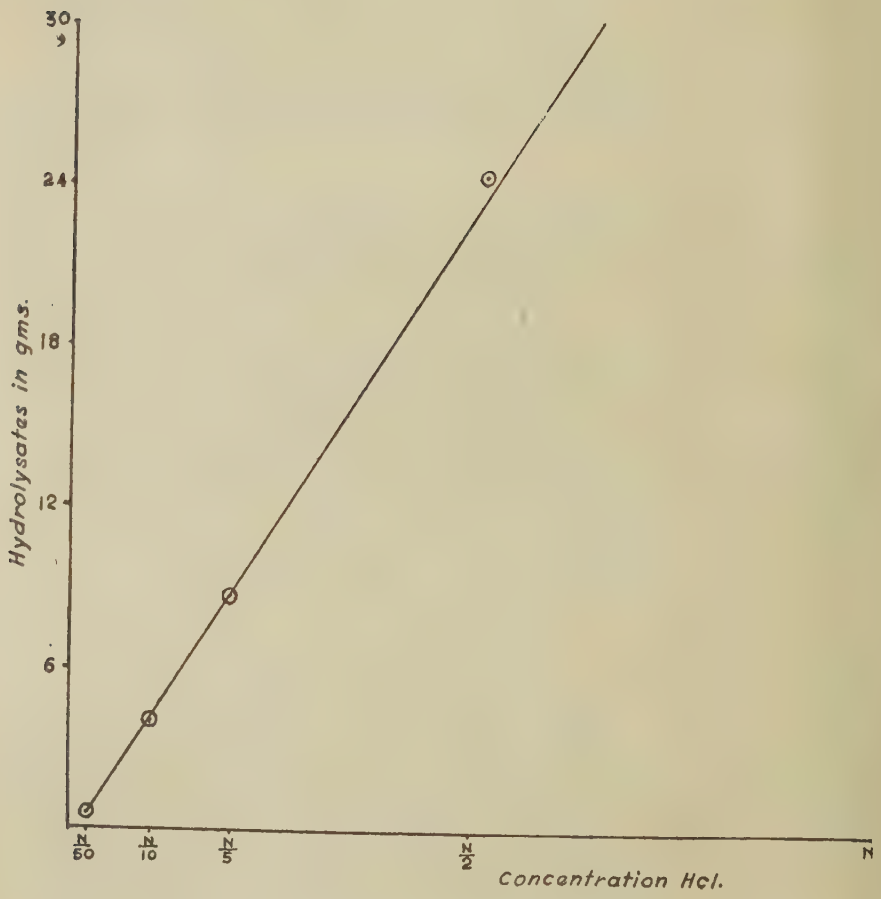


FIG. 1. Alcohol soluble hydrolysates

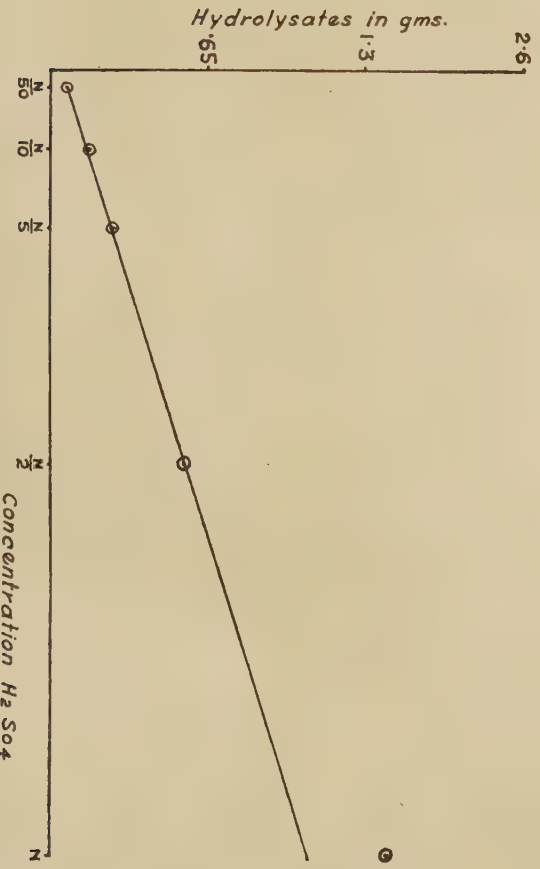


Fig. 2. Alcohol soluble hydrolysates

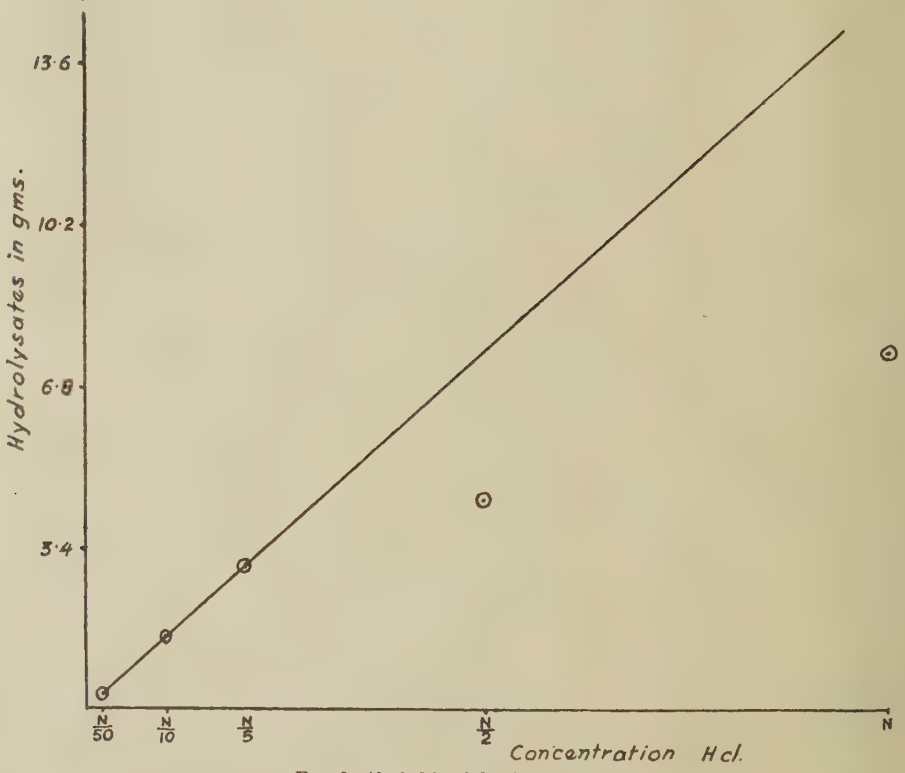


FIG. 3. Alcohol insoluble hydrolysates

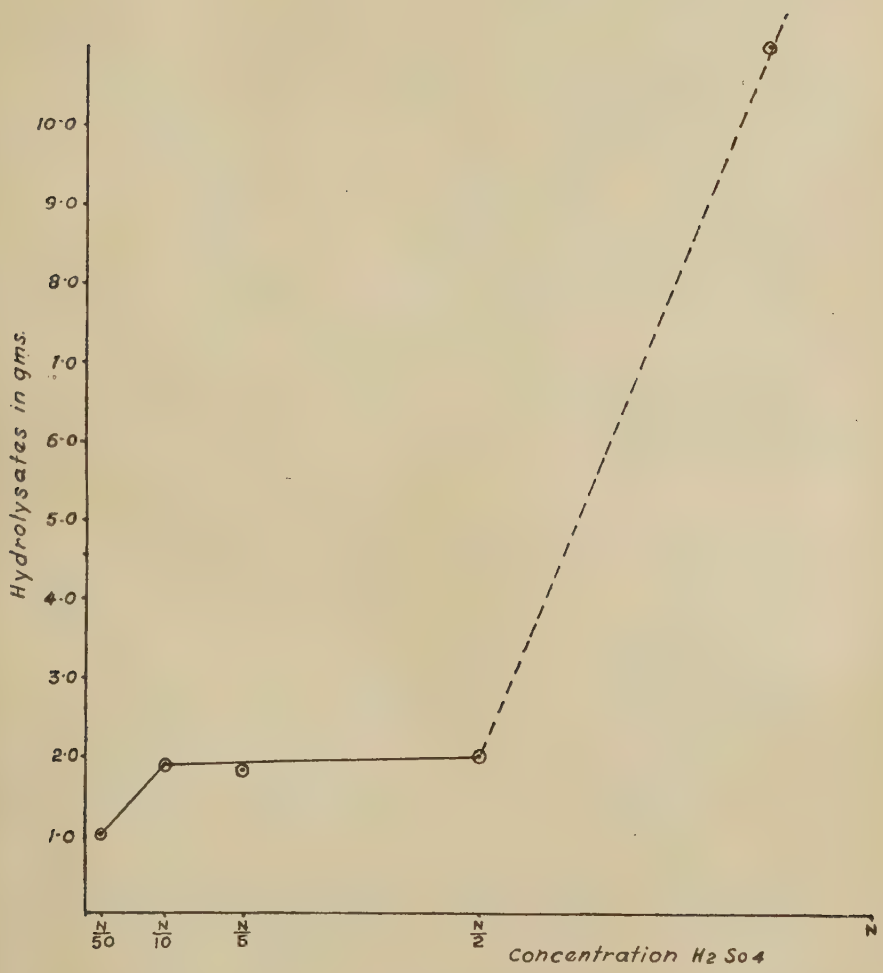


FIG. 4. Alcohol insoluble hydrolysate

The tables giving the yields of hydrolysates are given below. They have also been represented graphically in Figs. 1-4.

TABLE I

Soil hydrolysates by HCl refluxations

Concentrations	Alcohol-soluble portion	Alcohol-insoluble portion
1. 1,000 c.c. of N/50	HCl 0·5930 gm.	0·3350 gm.
2. 1,000 c.c. of N/10	HCl 4·0646 gm.	1·5470 gm.
3. 1,000 c.c. of N/5	HCl 8·8200 gm.	3·0100 gm.
4. 1,000 c.c. of N/2	HCl 24·2186 gm.	Sticky mass of inconsistent weight.
5. 1,000 c.c. of N	HCl Very moist and viscous mass of inconsistent weight.	7·4140 gm.

Table I shows that alcohol soluble hydrolysate is greater in the case of HCl but in the case of H_2SO_4 alcohol soluble portion is less than the alcohol insoluble fractions (Table II).

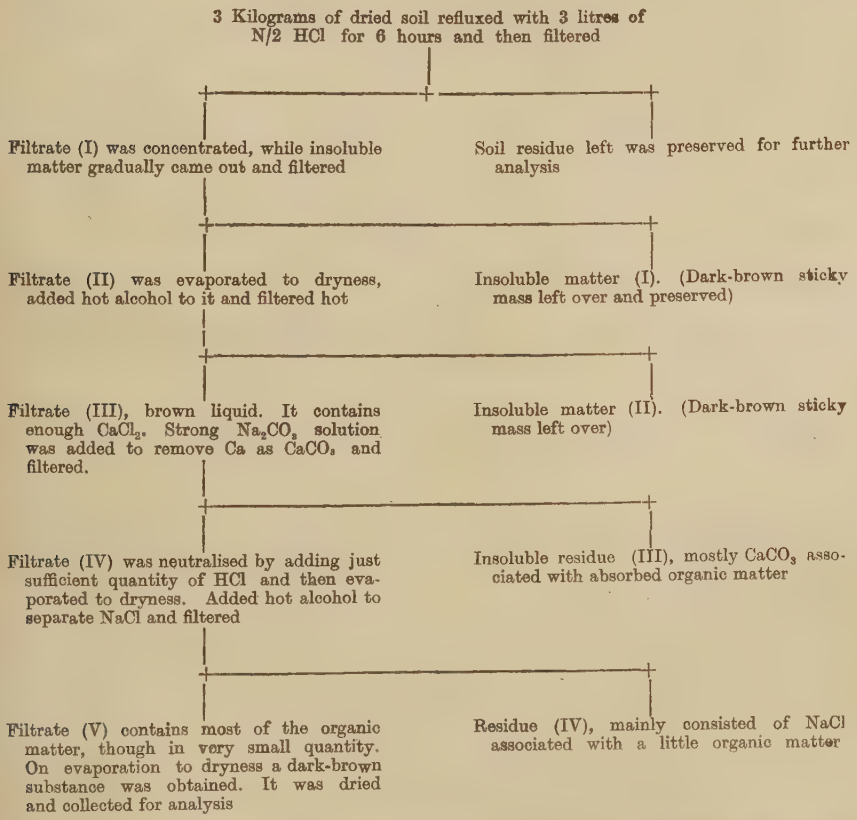
TABLE II

Soil hydrolysates by H_2SO_4 refluxation

Concentrations	Alcohol-soluble portion	Alcohol-insoluble portion
1. 1,000 c.c. of N/50	H_2SO_4 0·0652 gm.	1·0110 gm.
2. 1,000 c.c. of N/10	H_2SO_4 0·1400 gm.	1·9290 gm.
3. 1,000 c.c. of N/5	H_2SO_4 0·2580 gm.	1·8400 gm.
4. 1,000 c.c. of N/2	H_2SO_4 0·5372 gm.	2·0166 gm.
5. 1,000 c.c. of N	H_2SO_4 1·4006 gm.	19·4600 gm.

The optimum concentration of HCl as well as of H_2SO_4 for hydrolysis indicated by the curves was semi-normal. Higher concentrations gave much higher and disproportionate yields which were of a very viscous and sticky nature, and were less suitable for analysis. The yield of the soil hydrolysates shows a big jump after the semi-normal strength of acid has been exceeded. The quantities of the moist, viscous mass thus obtained far exceed the proportionate increase in the strength of acid beyond N/2. It suggests that the hydrolysates obtained from the soil organic matter are mixtures of variable composition depending upon the concentration of the acid. It is probable that there is uniformity of the composition of the hydrolysates up to the semi-normal strength as is shown by the straight line curves. Beyond the semi-normal strength the decomposition of the organic matter becomes more complex : hence the discontinuity of the curve shown by a sudden yield-jump takes place when normal and twice normal strengths of the acid are used.

Bremner and others have used 6 N. HCl, to extract the soil organic matter. In view of the complexity of the product that is obtained by his method, we limited our refluxations to N/2 HCl for the present. Hydrolysis with stronger HCl will be taken up later on. We have, therefore, used N/2 HCl as the most suitable hydrolysing agent for the soil organic matter, the so-called humus constituent. The process of our attempts to separate the inorganic matter from the alcoholic extract has been rather elaborate, and is briefly mentioned by means of the following sketch :



Proceeding with the analysis according to the above sketch we have found that the soil organic matter is so firmly bound up with the inorganic constituents, particularly calcium, that it is proving an uphill task to isolate even a very small quantity of the hydrolysed fraction of the organic matter in a state absolutely free

from the inorganic ; moreover, sufficient organic matter present in filtrate (I) is adsorbed by $CaCO_3$ during precipitation of filtrate (III). We are trying to devise some methods to minimise the adsorption of organic matter by $CaCO_3$ and also to extract the adsorbed organic substance from the precipitated $CaCO_3$. It has been interesting to observe that some organic matter is also rendered insoluble during the concentration of HCl-extract (vide insoluble matter (I) in the sketch). Attempts are being made to identify the composition of this residue which may be a polymerised form of a simpler substance in the HCl-extract.

We have been able to identify qualitatively the presence of some elements in the filtrates and the residues obtained during the process. Our observations are being summarised as follows :

——	Organic	Inorganic
Insoluble matter (I) .	Elements—N and Cl Molisch's test positive ; a member of the carbohydrate family.	Fe, Al, Ca, Mg, Cl, and PO_4.
Insoluble residue (II) .	Elements—N (faint) S and Cl. Molisch's test negative.	Fe (traces), Al, Ca (appreciable) Mg, Cl, PO_4 and SO_4.
Filtrate (V) . . .	Elements— N and Cl, S—absent, Molisch's test positive.	SO_4 and PO_4—both negative. Mg present only in traces.

From the above table of identified elements it is evident that a nitrogen compound and a carbohydrate must be products of hydrolysis of the soil under investigation. Among inorganic elements—Fe, Al, Ca and Mg are the bases which are present along with the acid radicals PO_4 and SO_4. The presence of chlorine may be ignored for the present because the soil was hydrolysed with HCl.

It is interesting to observe that the insoluble residue (II) gave an elementary detection of sulphur by sodium nitroprusside test. It suggests that either an inorganic sulphate or an organic sulphur compound insoluble in alcohol may also be one of the decomposition products during the hydrolysis of the soil.

Elaborate experiments are in progress to identify the hydrolysed products by evolving special methods for the study of such complicated mixtures as are obtained by the decomposition of the soil constituents.

Here a reference may be made to the fact that Kojima [1947] and Bremner [1949] have established that at least one-third of organic nitrogen of the soil is of protein nature. Very little is known of the presence of the large amounts of extraneous inorganic material in the soil hydrolysates. In a most recent communication in *Nature*, 4th March 1950, the details of which have not yet

been published in any journal. Bremner has been able to identify a number of amino-acids as a result of preliminary examination by the paper-chromatography technique. An elaborate scheme to investigate the soil organic matter by purely chemical as well as physical methods is in progress in our laboratories.

Acknowledgments

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METHODS OF SOIL SURVEY IN DIFFERENT COUNTRIES OF THE WORLD

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THERE is not a single branch of farming that is not dependent for its success in some measure on the characteristics of the soils of a region, nor is there any single country that can afford to be indifferent to the prosperity of its farming community. If, therefore, a soil survey chiefly aims at determining the soil characteristics of a region, its necessity and importance for any country need no special emphasis.

A soil survey, including its related chemical studies is an inventory of the soils of a region, classifying, describing and showing their distribution on a map, with the ultimate purpose to convey the information about the potentialities of land-use. Thus the aim of a soil survey is admittedly utilitarian, but its importance to the pedologist consists in an elucidation of the regional relationships of soils and the influence of climate, parent material and topography on soil genesis. Although the fundamental principles of soil survey work are the same in all countries, differences in the execution of work would appear inevitable due to puzzling patterns in soil distribution, and the varied aims and objects of the different surveys. Methods of survey practised and the experience gained by the workers in different countries, where soil survey work made considerable progress, would doubtless be of interest to the rest of the world, besides serving to guide the conduct of a more or less similar work. It was, therefore, thought desirable to study the development of soil survey work, with particular reference to the methods of survey, classification and cartography in different countries of the world, and the present paper is an attempt to that end. In this attempt a singular difficulty was the absence of literature in English on the Russian methods of soil survey, but, however, this did not detract to any marked degree the present review, as soil surveys carried out in the advanced countries of the world were all based on the Russian School of Pedology in which the soil profile forms the unit of soil study and classification.

United States of America

The soil survey organisation of the United States, known for its characteristic thoroughness of detail, admittedly stands foremost in the world. Almost all soil survey projects in the United States are the joint effort of a State authority and a Federal authority, the latter being the Soil Survey Division of the Bureau of Plant Industry, Soils and Agricultural Engineering—the Soil Conservation Service also co-operating with them at present. The U. S. Soil Survey staff works under the auspices of the Agricultural Experiment Stations, the Land Grant Institutions or the Universities.

Three types of soil survey are generally recognised viz., (i) Detailed (ii) Reconnaissance and (iii) Detailed reconnaissance. In detailed soil surveys, soil boundaries are plotted accurately from frequent observations made throughout the traverse. A modern basic detailed soil survey culminates in a comprehensive map portraying the individual soils. Reconnaissance soil surveys are those in which soil boundaries are sketched from observations made at wider intervals as these are less intensive and are chiefly in use for preliminary exploration work of an unknown area. A detailed reconnaissance survey is a combination of the above two as a part of the agriculturally more important area is surveyed by detailed method and the remainder by reconnaissance method.

In any of the above three types of survey, the soil profile is the principal unit of soil study and is the basis of soil classification. Soils with similar or nearly alike profile characteristics are grouped into 'series' and named after the locality where it was first recognised. The recognised textural classes of a series form the types and go by a binary nomenclature, consisting of the series name and the textural class. On the basis of characteristics of the soil or of the landscape of which the soil is a part and which assumes importance in land-use planning (but not differentiating characteristics of the profile) phases are recognised, of which the principal ones are the slope, stoniness and erosion. In areas where soil series, types or phases exist in such intimate mixture, that they cannot be indicated separately on soil map on practical scale, the term 'Complex' is employed only to facilitate mapping. Finally, areas where no soil character is present and even areas of non-agricultural importance are known as the ' Miscellaneous land units ', and are mapped as such. Thus soil survey essentially consists of (i) the delineation of series and types in the area based on profile studies (ii) demarcation of soil boundaries in the field on the base map (iii) framing the mapping legend and (iv) cartography. The first two are carried out in the field and the rest in the office. Besides these a report embodying information on agricultural, topographical, climatological, social and economic matters of the area is a necessary integral part of the survey work. The soil map with such a report is the end product of a soil survey of an area.

In detailed soil surveys, the base map is 4 inches to 1 mile and items of study are : soil complex, series, types and phases ; geology of the parent material, classification of rocks and identification of minerals ; general and broad features of vegetation ; all the climatic factors and detailed study of topography in very few cases, whereas in reconnaissance soil survey the base map is 1 inch to a mile and the items of study are : soil complex and soil association ; rock classification ; brief description of general climatic factors ; simple and complex slopes.

Canada

Interest in soil survey of Canada as pointed out by Stobbe [1948], was the result of a lamentable experience of a long period of unsatisfactory farming conditions. Today soil surveys are being conducted by all the provinces in co-operation with the provincial departments of agriculture, the colleges, experimental farms, and the Dominion Department of Agriculture and co-ordinated by the National Soil Survey Committee at Ottawa. Earlier soil surveys largely based on textural

classification of soils, were replaced by more modern methods that fall in line fundamentally with that adopted in the United States. Abroad reconnaissance or a preliminary survey wherein soils are examined at fairly wide intervals is a unique feature of the country, in that it is not adopted elsewhere and is reported by Stobbe [1948] to have greatly aided in getting at an approximate inventory of soils in a much shorter time. The reconnaissance surveys are the dominant surveys in the settled sections of the country. The recognised soil units are the more or less well defined ' soil associations ' and the series and types, the same information is being portrayed on a map of suitable scale.

A field classification of the soils for use in soil survey as adopted in Canada was given by Ellis [1932]. In principle, as stated by Ellis, it is essentially the Nikiforoff's system of field classification. The basis of the scheme is the grouping together of the same geological parent material in any given physiographic region. The associations which are found in any given physiographic region constitute a ' combination ' and the combinations in a climatic soil region or belt constitute a ' zone '. The classification therefore runs as follows :

Zone—Combination—Association—Associate—Phase. The differentiation of the associates in an association is on the basis of drainage conditions. The National Soil Survey Committee at its meeting in Ottawa in 1945 after careful consideration of the existing concepts on the classification units recognised seven units in the following order : Soil region—Soil zone—soil sub-zone—soil associations or catenas —soil associate or series—type or class—Phase.

In Canada, in detailed soil survey the base map is 4 inches to a mile and the items of study are : associations, series and types ; parent rock classification according to age ; plant species and plant communities ; general climatic conditions and a general description of topography whereas in reconnaissance survey the base map is 1 inch to a mile and items of study are : soil complex ; recognition and identification of surface geological features ; plant communities ; general features of the climate and topography in some detail.

Germany

It must be admitted at the outset, that little or no literature in English is available dealing with the methods of soil survey, classification and cartography followed in this country. However, information given below, was culled out from a singular, but authoritative Russian paper of Vilensky [1944], an English translation of which was available.

In Germany, soil science originated in the middle of the 19th century, but only as a branch of geology and agronomy. Later developments were indubitably related to the diffusion of ideas and methods of Dokuchaev School of Pedology. The first attempt to study soils according to Dokuchaev method was made by Stremme in 1914, and the first schematic maps of soil types were published in 1924 and 1926. A more detailed cartographic picture of Germany was given by Stremme in 1927 in the soil map of Europe, compiled by him for the First International Congress of Soil Science. In this map are shown all the soil types determined by

Russian soil scientists and the Russian nomenclature is on the whole accepted. From that time onwards soil investigations according to the method of Dokuchaev were begun in the different provinces of the country and soon soils maps of the provinces came into being, using Russian types and nomenclature. In 1935 a combined soil map of Germany was published on a scale of 1 : 1,000,000 compiled by Stremme [1936].

England and Wales

In England and Wales the development of soil survey has been exceedingly slow and has grown, in fact, out of advisory work with which it has always been associated. Surveys for this reason, have been almost entirely confined to agricultural soils. Systematic soil survey began in the year 1930, and since 1946 it is being carried on from Rothamstead with Dr A. Muir as its Director. Earlier soil surveys largely based on the geology of the parent material were replaced by the modern American methods with such minor modifications as were found necessary to suit local conditions. The two main aspects of the survey are (i) a field study of the soils morphology and mapping of the soils and (ii) analytical work in the laboratory to enable confirmation of the field observations. A notable feature of soil classification is that series are grouped, for convenience of statement, as observed by Robinson [1931], into 'Suites', each suite comprising soils derived from the same or similar geological material and yielding its different series by variations in the mode of occurrence and formation of constituent soils.

In detailed soil survey the base map is 6 inches to a mile and the items of study are : series with key letters or numbers relating to field descriptions (texture) ; mineralogy of the rocks and their detailed classification ; detailed climatic factors and topography not in great detail whereas in reconnaissance survey the map is 1 inch to a mile and the items of study are : suites with key letters or numbers relating to field descriptions ; rock composition ; broad features of vegetation ; general climatic factors and general topographic features.

Scotland

A systematic and detailed soil survey of the country on a nationwide scale was so far not carried out except for a small part, viz., Aberdeenshire. The basis of soil survey and soil classification is the nature of the well drained soil profile which in Scotland means the Podsolic group, with its several associated varieties representing the varied intensities in the podsolic weathering. Great importance is attached to the geology of rock formations in this country as it is almost the guiding principle in the identification of soil differences [Hart, 1944], as climatic differences are too little to merit consideration.

With reference to actual technique of soil mapping, Glentworth [1946] points out that since emphasis must be placed on the characteristics of the soil profile, there is no satisfactory short cut to much laborious digging, the frequency of which depends on the type and object of the survey.

In soil classification the first division is made according to the character of the present material, climate being uniform. This is an ' association ' which is a group

of soils developed on the same parent material under the same climatic conditions. The association is further sub-divided into ' associates ' or ' series ' which represent the major profile types produced by differences in drainage. The system of classification is thus based on a hydrologic sequence. The general scheme of classification of soils of Scotland has been diagramatically presented by Glentworth and Dion [1949].

In the detailed soil survey in Scotland the base map is 6 inches to a mile and the items of study are : associations and series ; detailed study of the solid geology of rocks and mineralogical composition of fine sand ; detailed study of vegetation in few cases ; brief description of temperature and rainfall data and general features of topography whereas in reconnaissance soil survey, the base map is 1 inch or 2·5 inches to a mile and the items of study are : association and series ; rock classification and mineralogical analysis of fine sand fractions ; general study of vegetation ; a brief description of climatic conditions and a general description of the topography of the area.

Australia

Extensive soil survey is being carried out in Australia under the auspices of the Council for Scientific and Industrial Research. Fundamentally the principle and methods of soil survey are the same as in the United States. The term ' spot surveys ' is frequently used for detailed type of soil surveys in the United States.

The technique of surveying in the country as recently reported by Prescott and Taylor [1949] is to select typical portions within the project area representative of differences in parent material, topography, drainage and vegetation and to survey these in detail. The practice has been to deal with units of from 5 to 10,000 acres in extent and by judicious selection of locations cover in full detail up to 5 per cent of the gross area in this way.

The field study consists in taking notes of topography, vegetation and drainage conditions, but special emphasis is invariably laid on lithographic materials. A study involving the comparison of the isologs of P/E (Precipitation divided by evaporation) with the soil and vegetation maps to find out the significance, if any, of P/E in its correlation with the soil and vegetation types—is a special feature in soil survey work of the country.

Soil samples for analytical work in the laboratory to confirm the field observations are drawn from the typical profiles dug out for the purpose. Besides the determination of physical properties and chemical composition of the soils, examination for trace elements are deemed important in problems of pasture and livestock management. In the light of the data so obtained agricultural and related problems are discussed and suitable recommendations are suggested in the report. Besides the principal soil map showing the distribution of soil types, drift maps indicating the major soil groups are occasionally included. Vegetation maps are prepared when data permit and a discussion of edaphic and climatic complexes are given [Northcote and Tucher, 1946]. Soil classification is essentially the same as in the United States.

In the case of detail soil survey in Australia, the base map is 1 inch to 10 chains for irrigation settlements, 1 to 20 for salinity survey and the items of study are : types for irrigation survey maps and complexes for others ; mineralogical analysis of fine sand factions supplemented by rock classification ; vegetation associations in relation to major soil groups ; general climatic conditions ; for topography, topo-sheets are used otherwise heights recorded with aneroid barometer whereas in the case of reconnaissance survey, the base map is 1 inch to a mile and items of study are : soil association, notes on geological formations and general features of climate.

Japan

Soil survey and soil mapping were not new to Japan, the first soil map having been prepared by the agronomy division of the Imperial Geological Survey, Tokyo, in the year 1882. Earlier soil surveys were however, entirely based on the geology of the rock system and the criteria in popular classification of soils was the texture. This was replaced in 1914 by the more modern methods and techniques as adopted chiefly in the United States and Russia. Among the types of soil surveys, the importance of reconnaissance soil surveys as a solution of the immediate problems of the country was emphasised by Swanson [1946]. To facilitate the conduct of such surveys and mapping the distribution of the several soils, the country was divided into eight areas and these are being surveyed one after another with the ultimate object of preparing a soil map in colour accompanied by a report in outline similar to that of the U. S. Department of Agriculture, for each of the surveyed areas. The survey, in fact, as pointed out by Swanson [1946] was one of a general nature and the soil map chosen was one of a small scale for delineation of the different soil groups.

South Africa

Marbut [1923] was perhaps the first to make a study and attempt at a classification of the soils of South Africa on a pedological basis. He also presented a soil map of the country which however, as admitted by him, cannot be regarded a soil map in the real sense of the term. Merwe's [1940] publication on the soil groups and sub-groups of South Africa along with a soil map can safely be said to be the only authoritative treatise on the subject, even to date. As admitted by him the soil map was not the result of systematic soil survey but of individual soil studies spread almost throughout the country. In drawing the soil boundaries on the soil map, topographical map, geological map and that of the vegetation were reported to be of great assistance. Most of the soil groups identified could be assigned their respective places in the International classification of Great soil groups.

East Africa

A provisional soil map accompanying a memoir embodying chiefly the classification of the main soil groups, their nature and properties, mode of formation and their relation to other physiographic features published by Milne [1936] is the only authoritative treatise relating to the soils of East Africa. The mapping of the soils of East Africa in general presented certain difficulties. In the first place a

large part of the country is dissected peneplain, with an ill-defined valley system. Secondly, ranging from crest to trough one finds particular type of soil passing through various gradations with the result that no individual soil series occupies a sufficiently large area to be mapped on a practical scale. These difficulties have however been met with by the suggestion of Milne [1935] that series should be mapped as one group and that group should be called a 'Catena '.

Fiji

Blackie [1949] admits that soil work in Fiji was mostly confined to routine field and laboratory examinations and at no time had any serious attempt been made in the study of soil morphology and genesis. In an undeveloped country like Fiji where the social factor does not operate to such an extent as in other countries detailed soil surveys and land inventories on the American model are unwarranted as they are both time and money consuming. The future policy of the country, therefore, according to Smythe [1947], is a reconnaissance soil survey and an inventory of defined soil types regarding their nutrient status and physical properties.

Java

Mapping of soils of Java was attempted independently by the Experiment Station for the Java Sugar Industry, a private organisation, and by the Institute of Soil Technology of the Department of Agriculture which is sponsored by the Government. The former conducted the work under the direction of Brick and soil maps published by him in 1932 carried a serious defect as pointed out by Pendleton [1934] in that the maps dealt with the surface soil only, the soil profile altogether having been ignored. The second organisation originally under the leadership of E. C. Jul and at present under Dr White, commenced soil survey work in 1930 and has to its credit a marked progress of actual classification and mapping of soils of large part of the country. The method adopted for this purpose is fundamentally the same as adopted in the United States, except for minor changes. Special emphasis on the suitability of the American method was laid by White [1931]. General soil maps and single factor maps accompany the soil survey report on lines similar to the American model.

New Zealand

A soil survey proper with land-use inventory on the lines parallel to U. S. was carried out in this country. Detailed mapping of the several of the localities of the Northern island was reported by Grange [1944] to have reached completion. An important feature of mapping was that topographical maps were used during the survey and where possible, vertical air photographs were made use of. Besides the principal soil map, single factor maps each depicting one particular land-use were also prepared.

Ceylon

In a country like Ceylon where intensive agriculture is not practised detailed traverse surveys of the American model are unwarranted, besides being prohibitively

costly. However, soil surveys of those areas proposed for development as colonisation under the new land policy of the Government, were conducted with the object of ascertaining the suitability of each area or any part of it for development—the types of soil comprising it, their distribution and the nature of the crops suited to each type. To this end no fewer than 96 surveys of the reconnaissance type have been carried out since 1935 as mentioned by Joachim [1945]. Of immediate importance to the island as pointed out by him [1938] was a determination of the main soil groups occurring along with their chief characteristics. Nine distinct soil groups were recognised and modern pedological principles and methods were adopted in their study through a systematic work both in the field and in the laboratory, taking two or three typical profiles to represent each of the nine groups. A tentative classification of these profiles with a view to assigning each of the nine groups to their respective place in the world system of great soil groups, was formulated. Drainage was given a prime consideration bringing all the soils into two broad classes according to whether the drainage is ' free ' or ' impeded '. Each class is further divided into various geological groups and further sub-division was based on climatic differences. Joachim [1945] gave a classification of the soils of the entire island based on deaphic factors, on the international system of zonal, intrazonal and azonal soils and then into series. A provisional soil map of the island showing the distribution of the major groups, series and types was given by him [1945].

India

While there has never been an All Indian Soil survey on the American traverse model, there have been a number of soil surveys dealing with limited areas for specific purposes. In all these cases such surveys were undertaken in connection with the solution of definite problems of local interest and of an immediate pressing need. The information thus collected is voluminous but necessarily fragmentary in character, being devoid of a common objective. The different surveys so far carried out may be classified as (i) fertility surveys to assess the nutrient status of surface soils, (ii) post or pre-irrigation surveys to recommend the desirability or otherwise of introduction of irrigation and (iii) systematic scientific surveys of soils on profile basis. The last one is of recent origin. The studies of the soils of the Deccan Canal area in the Bombay-Deccan by Basu and Sirur [1938]; the Tungabhadra soil survey in the Madras-Deccan by Ramiah [1937]; and of the Gangetic alluvium by Mukherji *et al.* [1946 and 1947] are some of the examples.

The soils of India were first classified by Leather [1898] who distinguished four major groups of soils, (i) the Indo-Gangetic alluvium, (ii) the black cotton or ' *regur* ' soils, (iii) red soils lying on metamorphic rocks and (iv) laterite soils. The relation between the broad soil zones of the country and the basic geological foundations has been discussed by Wadia *et al.* [1935]. The importance of geology as a factor largely contributing to a rational differentiation of the broad soil groups of India was underlined by Wadia [1949]. On the basis of climate Champion [1936] divided the soils of India and Burma into fifteen climatic types pointing out the inadequacy of both the climate and the geology as a basis of classification. Basu

[1937] classified the Indian soils into eight broad groups. It must be admitted that in view of the lack of adequate scientific data in respect of the whole country any of the above classifications is necessarily provisional.

A soil map of the type that exists for the U. S. is not available for India. The first attempt to correlate the available data was made by Scholasky [1928] who published a soil map of India on the Russian System. Champion [1936] presented a map showing the climatic types. A soil map showing the boundaries between the different general types of soils was given by Wadia *et al.* [1935], pointing out the fact that the approximate boundaries of these soil groups are nearly co-terminous with the boundaries of the geological outcrops. The soil map of India prepared by Viswanath and Ukil [1944] portrayed the different climatic types for which the basis was the N-S quotient. Based on comparative studies on 49 selected soil profiles of India, Viswanath and co-workers [1944] adopted colour and texture as units of classification and these in turn were treated on a background of four major climatic zones viz., arid, semi arid, humid and per humid. Soil maps of the various States and a revised soil map of India were prepared in the year 1946, under the auspices of a scheme financed by the Indian Council of Agricultural Research, for which the existing data in respect of them was utilised.

Conclusion

The review is an attempt to present a broad and general picture of the organisation, development and methods of soil survey work in more important countries of the world. An attempt has been made to present all information relevant to methods of soil survey and soil classification, in a manner to facilitate the reader to get a comparative idea for the different countries. No attempt was made to give out the actual working details for survey work as it is largely dependent on the special features of the area and the objects of the survey. As a general guide for soil survey work the classical and authoritative Manual of Kellogg [1937] is highly commendable. The countries with temperate climate are far ahead of the tropics in the matter of soil surveys and their practical utilisation. This is partly attributable to the inherent limitations of the tropics such as the vast stretches of impenetrable forest areas and the threat of deadly diseases like malaria, etc. So far as India is concerned, a preliminary rapid reconnaissance survey will be useful followed by planning for detailed surveys in the problem areas or areas intended to be intensively developed in the different states.

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EFFECT OF PHOSPHATE MANURING WITH AND WITHOUT POTASH ON THE YIELD AND QUALITY OF BERSEEM FODDER

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THE results of numerous field trials [Blaser, Volk and Smith, 1941 ; Erdman and Wilkins, 1928 ; Mursell, 1944 ; Parr and Bose, 1944 ; Robinson, 1942 ; Stitt, 1944 ; Truesdell, 1917 ; Wohltmann and Bergene, 1902 ; West, 1936] have shown that legume fodders (alfalfa, lucerne, soybean, etc.) respond remarkably well to the application of phosphate fertilizers. There is evidence to indicate [Greaves and Pitman, 1946 ; Parr and Bose, 1944 ; Rogers and Sturkie, 1939 ; Sewell and Latshaw, 1931 ; Singleton, Nelson and Stanberry, 1945] that the application of phosphate results in the production of fodders of better quality. Application of potash is also said to have increased the protein content of soybean [Fellers, 1918] and alfalfa and peas [Mac Taggart, 1921].

In this paper are presented the results of a field experiment conducted to test the effect of superphosphate alone and in combination with potassium sulphate on the yield and quality of berseem fodder.

Material and method

The undermentioned fertilizers were applied to berseem before sowing during the years 1946-47, 1947-48 and 1948-49. Unmanured *guar* was grown in the *kharif* in rotation with berseem. *Guar* failed in all the three years due to waterlogged condition.

Table I

Amount of P_2O_5 and K_2O applied per acre

Fertilizer treatment	P_2O_5 lb.	K_2O lb.
A. Control (No manure)	0·0	0·0
B. Superphosphate	50·0	0·0
C. Superphosphate	100·0	0·0
D. Superphosphate + Potassium sulphate	50·0	80·0
E. Superphosphate + Potassium sulphate	100·0	80·0

The experiment was laid out in randomised blocks with six replications and a plot size of 1/40 acre.

The crop was sampled at each cutting and was analyzed chemically for N, P_2O_5 and CaO during the years 1946-47 and 1947-48. In 1948-49 composite samples from all cuttings were analyzed.

The chemical analysis of the soil carried out before starting the experiment showed the following results :

	Per cent
Nitrogen	0·058
Total P_2O_5	0·077
Available P_2O_5	0·026
Total K_2O	0·583
Available K_2O	0·015
CaO	0·691

The soil was found to be rich in available P_2O_5.

Yield of berseem green fodder

The yield of berseem green fodder obtained from four cuttings in 1946-47 and 1947-48 each and from six cuttings during 1948-49 and the average yields of three years are given in Table II. Two extra cuttings were obtained in 1948-49 due to better growth of the crop than in the preceding years.

TABLE II

Average yield of green berseem in maunds per acre

Treatment	1946-47	1947-48	1948-49	Average of 3 years
A. No manure	515·47	577·59	552·49	548·39
B. 50 lb. P_2O_5	583·24	645·12	755·67	661·34
C. 100 lb. P_2O_5	585·98	641·65	748·76	658·79
D. 50 lb. P_2O_5 + 80 lb. K_2O	502·57	626·99	771·23	633·59
E. 100 lb. P_2O_5 + 80 lb. K_2O	553·80	627·23	739·36	640·13
S. E. mean	±35·54	±19·95	±37·70	±21·48
C. D. at 5 per cent	104·83	58·87	111·22	63·36
'F' test	Not sig.	Sig.*	Sig.**	Sig.**

* at 5 per cent level ; ** At 1 per cent level

A statistical study of the yield data indicated that during 1946-47, the differences in yields due to the different treatments were not significant. During 1947-48, treatments B (50 lb. P_2O_5) and C (100 lb. P_2O_5) yielded significantly higher than the control. During 1948-49, all the manurial treatments out-yielded the 'no manure' control, and the differences were significant at the 1 per cent level. However, there was no significant difference between the yields of any two of the fertilizer treatments.

A combined analysis of the yield data of three years shows that superphosphate at 50 lb. P_2O_5 per acre was the best treatment giving the highest yield. The higher dose of superphosphate at 100 lb. P_2O_5 or the addition of potash to the phosphate doses was ineffective.

Effect of season on yield

The interaction between treatments and seasons was calculated to ascertain whether or not the treatments have shown any differential response to the change in the climatic conditions from 1946-47 to 1948-49. The only statistically significant components in this analysis were treatments and seasons. The interaction was not significant and it can be assumed that the treatments have maintained the same relative position for three years. The variance due to seasons was also significant. The yields of berseem green fodder for the three years are given in Table III.

TABLE III

Average yield of green berseem in maunds per acre

Year	Yield
1946-47	548·21
1947-48	623·72
1948-49	713·43
S.E. mean	19·50
C.D. at 5 per cent	57·52

The highest yield of the year 1948-49 was significant over that of 1947-48 which in turn was significant over yields obtained during 1946-47. The increasing trend of yields from year to year shows the cumulative effect of the manures applied. The high yield in 1948-49 is due partly to the extra two cuttings afforded by the better growth of the crop than the former two years.

Chemical composition of berseem fodder

The results of chemical analysis of berseem fodder on dry matter basis are given for each cutting in Table IV for the years 1946-47 and 1947-48. Table V gives averages of all cuttings for each of the three years.

Table IV

Per cent nitrogen (N), phosphorus (P_2O_5) and calcium (CaO) contents of berseem on dry material basis

1946-47

Treatment per acre	1st cutting			2nd cutting			3rd cutting			4th cutting		
	N	P_2O_5	CaO	N	P_2O_5	CaO	N	P_2O_5	CaO	N	P_2O_5	CaO
A. No manure	4·1	0·61	2·7	3·3	0·52	2·9	2·5	0·36	3·1	2·9	0·44	3·4
B. 50 lb. P_2O_5	4·0	0·74	2·9	3·0	0·71	3·3	2·3	0·43	3·2	2·8	0·53	3·7
C. 100 lb. P_2O_5	4·0	0·89	2·7	3·3	0·95	3·2	2·5	0·55	3·2	2·7	0·55	3·5
D. 50 lb. P_2O_5 + 80 lb. K_2O	4·1	0·78	2·8	3·1	0·59	2·8	2·5	0·53	3·2	2·8	0·55	3·3
E. 100 lb. P_2O_5 + 80 lb. K_2O	4·1	0·97	2·8	3·3	0·84	3·3	2·4	0·57	3·3	2·9	0·57	3·6

1947-48

A. No manure	3·9	0·65	3·3	3·3	0·64	3·3	3·0	0·41	4·0	3·0	0·44	4·6
B. 50 lb. P_2O_5	3·9	0·96	3·2	3·2	0·86	3·4	3·1	0·60	4·3	2·7	0·51	4·9
C. 100 lb. P_2O_5	3·9	1·12	3·5	3·0	1·07	3·6	3·2	0·75	4·5	2·7	0·58	4·8
D. 50 lb. P_2O_5 + 80 lb. K_2O	4·0	0·81	3·8	3·6	0·93	3·5	2·7	0·59	4·4	2·8	0·52	4·9
E. 100 lb. P_2O_5 + 80 lb. K_2O	3·9	1·14	3·6	3·3	0·69	3·4	3·2	0·66	4·6	2·7	0·53	4·8

TABLE V

Chemical analysis of berseem fodder on dry material basis

(Average of all cuttings)

Year	Constituents	Treatments					
		A No. manure	B 50 lb. P_2O_5	C 100 lb. P_2O_5	D 50 lb. P_2O_5 +80 lb. K_2O	E 100 lb. P_2O_5 +80 lb. K_2O	Average
1946-47	N	3·20	3·02	3·12	3·12	3·18	3·13
	P_2O_5	0·48	0·61	0·74	0·61	0·74	0·64
	CaO	3·02	3·28	3·15	3·02	3·25	3·14
1947-48	N	3·30	3·22	3·20	3·28	3·28	3·26
	P_2O_5	0·54	0·73	0·88	0·71	0·76	0·72
	CaO	3·80	3·95	4·10	4·15	4·10	4·02
1948-49	N	3·70	3·50	3·90	3·80	3·50	3·68
	P_2O_5	0·71	0·92	0·87	0·65	0·70	0·77
	CaO	2·80	3·10	2·90	3·10	3·10	3·00
Average	N	3·40	3·25	3·41	3·40	3·32	3·36
	P_2O_5	0·58	0·75	0·83	0·66	0·73	0·71
	CaO	3·21	3·44	3·38	3·42	3·48	3·39

Nitrogen. In general, fertilizers had little effect upon the nitrogen content. The first cutting showed the highest percentage of nitrogen followed in order by second, third and fourth cutting in both the years. In 1946-47, the nitrogen percentage in the fourth cutting was slightly higher than that obtained in the third cutting.

Phosphorus. Manuring of berseem with phosphatic fertilizer resulted in substantial increase in the P_2O_5 content of the hay. The greatest increase was from superphosphate at 100 lb. P_2O_5 per acre alone or in combination with potash. Crop from the first cutting contained the highest percentage of P_2O_5 and it declined in the subsequent cuttings, but the trend of response due to the fertilizer treatments was maintained.

Calcium. Calcium content of the hay was slightly increased as a result of the application of fertilizers over that of the check plots.

Total recovery of N, P_2O_5 and CaO

Table VI gives the total amount of N, P_2O_5 and CaO recovered by the crop under the different fertilizer treatments during three years. Average recovery of N, P_2O_5 and CaO for three years has also been calculated.

TABLE VI

Total intake of N, P_2O_5 and CaO in lb. per acre

Constituents	Year	A No manure	B 50 lb. P_2O_5	C 100 lb. P_2O_5	D 50 lb. P_2O_5 + 80 lb. K_2O	E 100 lb. P_2O_5 + 80 lb. K_2O
N	1946-47	255·03	244·98	268·44	241·05	255·35
	1947-48	231·93	235·02	224·51	235·52	238·85
	1948-49	310·30	326·90	372·60	355·00	341·30
	Average	265·75	268·97	285·18	277·19	278·50
P_2O_5	1946-47	38·33	52·44	64·39	47·31	60·39
	1947-48	36·13	51·10	60·14	49·69	49·69
	1948-49	59·40	85·00	83·30	80·20	68·64
	Average	44·62	62·85	69·28	52·40	59·57
CaO	1946-47	244·46	285·06	274·54	241·80	275·81
	1947-48	288·57	318·94	325·26	330·24	310·23
	1948-49	235·70	286·30	275·80	286·40	397·90
	Average	256·24	296·77	291·87	286·18	297·98

Nitrogen. The highest average intake of N was by the crop from plots treated with superphosphate at 100 lb. P_2O_5 which was 285·18 lb. per acre, about 20 lb. more than that of the control. The highest recovery was obtained during 1948-49 which was the highest yielding year.

Phosphorus. The highest recovery of P_2O_5 was also from plots treated with 100 lb. P_2O_5 per acre. The quantity recovered in the crop was 69·28 lb. per acre which was about 25 lb. more than the recovery in the control plots. The increase in the recovery of P_2O_5 due to the application of 50 lb. P_2O_5 per acre was about 18 lb. over the control. The addition of potash to phosphate has decreased the intake of P_2O_5 of the crop as compared to the crop fertilized with phosphate alone. It was observed that the average annual recovery of P_2O_5 in the control plot is 44·62 lb. per acre.

The highest quantities of P_2O_5 recovered were in 1948-49 which was also the highest yielding year.

Calcium. Substantial increases in the total intake of CaO by the crop have been effected with the application of 50 lb. P_2O_5, 100 lb. P_2O_5 and 100 lb. P_2O_5 plus 80 lb. K_2O per acre. The addition of 80 lb. K_2O to 50 lb. P_2O_5 decreased the intake of CaO as compared to 50 lb. P_2O_5 alone.

The highest recovery of CaO was in 1947-48 which is the year of medium yield and of N and P_2O_5 recovery.

Discussion

The yield results of berseem fodder showed a marked increase due to manuring with phosphate over the control as observed by several workers [Blaser, Volk and Smith, 1941 ; Erdman and Wilkins, 1928 ; Mursell, 1944 ; Parr and Bose, 1944 ; Robinson, 1942 ; Stitt, 1944 ; Truesdell, 1917 ; Wohltmann and Bergene, 1902 ; West, 1936] . The yields of the control plots were consistently maintained and did not show any decline. This may be attributed to the high content of available P_2O_5 in the soil. The application of potash in combination with P_2O_5 depressed the yields slightly as compared to P_2O_5 alone, though not significantly. The quality of the fodder showed marked improvement in respect of phosphate content and slight improvement in respect of calcium content by phosphate manuring. The nitrogen percentage was not increased due to manuring. An increase in the P_2O_5 content of the fodder was observed with the corresponding increase in the dose of application of phosphate to the crop, though the higher dose did not give increased yield of fodder over the lower dose. Due to higher yields obtained from the manured plots, the total recoveries of N, P_2O_5 and CaO were higher than the control plots.

These results are in close conformity with those reported by other workers [Parr and Bose, 1944 ; Rogers and Sturkie, 1939 ; Sewell and Latshaw, 1931].

Summary

An experiment was conducted at the Indian Agricultural Research Institute Farm, New Delhi, during the years 1946-49 to study the effect of superphosphate applied at 50 lb. and 100 lb. P_2O_5 per acre singly and in combination with potassium sulphate at 80 lb. K_2O per acre on the yield and quality of berseem fodder. The soil of the plot is clayey loam with 0·058 per cent nitrogen, 0·077 per cent total and 0·026 per cent available P_2O_5, 0·58 per cent total and 0·015 per cent available K_2O and 0·69 per cent CaO. Berseem was rotated with unmanured *guar* which failed due to heavy rains in the *kharif* season every year.

The results obtained in these investigations are summarised below :

(1) The application of superphosphate alone or in combination with potash brought about marked increases in yield over the no manure control in the last two years of the trial. Their effects were not fully exhibited during the first year due to the late sowing of the berseem crop.

(2) Superphosphate applied to berseem at the rate of 50 lb. P_2O_5 per acre annually was as effective as the double dose, i.e., 100 lb. P_2O_5 per acre in maintaining the yield of berseem.

(3) Potassic fertilizer applied in combination with superphosphate did not influence the yields greatly or consistently.

(4) Superphosphate applications materially increased the P_2O_5 content and slightly increased the CaO content in the plant material, thereby improving the quality of the fodder for feeding purposes. Though the treatments did not show significant differences in yield in the

first year, the P_2O_5 content due to phosphate manuring was higher than the control.

(5) The crop from plots treated with 100 lb. P_2O_5 per acre showed a higher percentage of P_2O_5 than that from plots treated with 50 lb. P_2O_5 per acre.

(6) The nitrogen content of the crop remained unaffected by the application of phosphate alone or in combination with potash.

(7) The highest recovery of N and P_2O_5 was from the crop treated with 100 lb. P_2O_5 per acre and that of CaO was from plots treated with 50 lb. P_2O_5 per acre or 100 lb. P_2O_5 plus 80 lb. K_2O per acre.

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*SOME IMPORTANT FINDINGS OF THE SUGARCANE RATOONING SCHEME AT KALAI (ALIGARH), UTTAR PRADESH

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RATOONS occupy about 30 per cent of the total cane area in the Uttar Pradesh. The practice of ratooning has undoubtedly its own importance in relation to the sugar industry, affording as it does an efficient means of minimizing the cost of production of sugarcane. The other advantage is that ratoons appear to come to maturity appreciably earlier than the plant cane crop. Formerly the practice of ratooning was not common in India, since the indigenous varieties were not very good ratooners. With the introduction of the improved Coimbatore canes which are very good ratooners, the practice of ratooning has gained popularity during the last two decades. In the eastern parts of the Uttar Pradesh and in the Western Terai area ratooning of cane for three to four years is quite common. In other parts of Uttar Pradesh first and second year ratoons are generally met with.

The practice of ratooning, however, has got its dark side as well. Besides putting a heavy drain on the soil, the ill-manured ratoons appear to serve as breeding grounds for the various sugarcane pests during their first brood in March and April. It is from the ratoons that the pests migrate to the plant crop during the months of May and June. The problem which thus arose was whether ratooning was a justifiable practice in the interest of the sugarcane growers as a whole and, if so, for how many years and under what conditions of management. With a view to getting an insight into the vexed problems connected with the ratooning practice, so common with the cultivators of Uttar Pradesh, experiments were conducted from January, 1939 to March, 1949 at the Government Seed Farm, Kalai, District Aligarh, for studying the following items :

(i) The effects of the different years of ratooning on the yield and quality of sugarcane.

(ii) The effect of manuring on ratoon crops.

(iii) The comparative economics of plant and ratoon crops.

(iv) The incidence of pests and diseases and their carry over through ratoons of different years.

For conducting the above investigations field experiments were laid out in two different designs. One was the 'Compact Block' design which was financed by the Indian Council of Agricultural Research till March 31, 1945 and subsequently by Indian Central Sugarcane Committee ; while the other—the 'Scattered Block' design was financed by the Uttar Pradesh Government. The main object of the latter

*Based on the final report of the work done under the Sugarcane Ratooning Scheme at Kalai (Aligarh) from January 1939 to March 1949.

was to make a study of the migration of various cane pests and diseases from ratoon to plant cane, growing in contiguity with ratoons of different years and also in segregated plots away from the ratoons.

In both the experiments plant cane, first, second and third year ratoons were taken, each in rotation with *juar* (*Sorghum valgare*) and *guar* (*Cyamopsis psoralioides*) fodder in *kharif* and wheat in *rabi* in the first year, and cotton and fallow in the second year, followed by plant cane and ratoons in succeeding years forming cropping schemes for three, four, five and six years.

Plant cane and manured ratoons in these experiments were given 100 lb. nitrogen per acre in the form of sulphate of ammonia and castor cake on 50 : 50 basis, Co. 312, the standard cane variety of the locality was used for planting.

Agronomical observations included germination counts, tillers per clump, number of canes formed, juice quality and yeild at harvest. Cost of cultivation of crops was carefully worked out for the compact block design experiment. Entomological observations which included the incidence of borers, termites, *pyrilla* and whitefly were recorded regularly during the crop season from April to December at monthly intervals. Records were also maintained for the incidence of diseases, e.g., mosaic, smut, red rot, stinking rot, top rot and the red stripe disease.

Results achieved are summarized below.

Tillering. Plant cane has the least number of tillers which show an increase with successive manured and unmanured ratoons. It appears that the tiller number per stool increases as the age of the ratoon advances. The number of tillers in manured ratoons is always greater than in the unmanured ratoons. The maximum tiller number per stool in each treatment is attained sometime in June or July, followed by a reduction in the tiller numbers. The rate of mortality of tillers is very high till the month of October. Subsequently only a few tillers die and the number of canes per stool remains almost at a constant level till harvest. The average mortality percentage is less in plant cane than in ratoon. There is practically no effect of manuring on the mortality percentage of tillers in ratoon.

TABLE I

The average yield of cane in md. per acre (1942-43 to 1948-49)

Treatments	Manured ratoons	Unmanured ratoons
Plant cane	754·26	..
Ratoon I	652·98	312·54
Ratoon II	543·55	236·30
Ratoon III	503·81	193·71

Cane yield. Plant cane gives the highest yield of cane per acre as compared to ratoons.

There is a progressive decline in cane yields with the increase in the age of the ratoon. Decrease due to ratoon I, II and III is 13·4, 27·9 and 33·2 per cent, respectively in the case of manured ratoons and 58·5, 68·7 and 74·3 per cent, respectively in the unmanured ratoons. The increase in yield of cane in the I, II and III year manured ratoons over the unmanured ratoons of the corresponding age is 340·4, 307·3 and 310·1 md. per acre, respectively. In other words, the increase per lb. of nitrogen applied is 3·4, 3·1 and 3·1 md. for the I, II and III year ratoons, respectively. It may be observed that this response to manuring in ratoons is at par, if not greater than what is generally obtained with plant cane.

Juice quality. It is noteworthy that manuring of ratoon not only increases cane yield but also improves the quality of cane, both in regard to the quantity (extraction per cent cane) and quality (sucrose and purity) of juice. Ratoons, irrespective of their age and manuring, show better juice quality than plant cane during the early season ; but the difference in favour of ratoon is narrowed down with the advance of the crushing season. This emphatically indicates the desirability of crushing ratoons in the early season for the manufacture of white sugar.

Cost of production. The average cost of production over seven years (1942-43 to 1948-49) comes to Rs. 339·7, Rs. 163·1 and Rs. 78·4 per acre for plant cane, manured and unmanured ratoons, respectively, which means lowering of cost of production by Rs. 176·6 in manured and Rs. 261·3 in unmanured ratoons as against that of plant cane. Apparently there is a considerable saving in unmanured ratoons ; but this saving being offset by reduction in the cane yield, the net returns per acre are affected adversely. The average net returns per acre in the I, II and III year unmanured ratoons work out to Rs. 280·5, Rs. 178·8 and Rs. 134·1, respectively ; while the net returns per acre in the corresponding manured ratoons are Rs. 591·4, Rs. 451·0 and Rs. 411·1, respectively, i.e., 110·9, 152·3 and 206·5 per cent in excess over their respective unmanured contemporaries. Thus it is obvious that the extra cost incurred in manuring ratoons is amply compensated by increased yield of cane.

Plant cane has given the highest gross income over all the other treatments, obviously due to its superior yields. But net profits per acre are lower than that of first year manured ratoons due to high cost of cultivation of plant cane. Each of the remaining ratoon treatment gives less net profits than the plant cane.

The cost of production figures as given in Table II establishes the fact clearly that there is a marked reduction in the cost of production in the first year ratoon as compared to plant cane, followed by a gradual rise in the cost with the age of the ratoon. Manuring of ratoon has helped in growing cheaper cane per maund, particularly in older ratoons.

It is the cheapness of production of cane per md. as compared to plant cane, which induces the cane growers to continue taking ratoons for several years in spite of definitely poor yields in older ratoons. This could perhaps be justified if there had been land in plenty. But in view of the pressing need for putting more land under food crops, this policy cannot be upheld, and ratooning for one year under good care and management only appears feasible.

TABLE II

Cost of production per md. of cane

Treatment	Cost of production in annas	
	Manured	Unmanured
Plant cane	7·2	..
Ratoon I	4·0	4·0
Ratoon II	4·8	5·3
Ratoon III	5·2	6·5

Pest incidence. Observations on insect pests and diseases in these experiments reveal that (1) the top borer and whitefly infestation are low in manured ratoon ; (2) the infestation of whitefly does not seem to spread from ratoons to plant cane, as the incidence is met with in all the treatments during the same month ; (3) the incidence of stem borer in cane is generally of a very low order in all the treatments. However, the infestation appears to affect the unmanured ratoons more than the plant cane and the manured ratoons than in the unmanured ratoons, although the observed differences in incidence are not statistically significant ; (5) borers and *pyrilla* first multiply on ratoon and then migrate to plant cane. This does not mean that the incidence of *pyrilla* will be checked in plant cane by growing plant cane segregated from ratoon, since almost the same intensity of infestation of *pyrilla* was recorded simultaneously in plant cane grown segregated and in contiguity with ratoons ; and (6) plant cane grown segregated had slightly less incidence of borers, whitefly and termites than the plant cane grown adjacent to ratoons.

Diseases of cane crop were not common in the locality where the experiments were conducted, and their occurrence was also not regular. Information on this aspect of ratooning is thus very meagre.

CONCLUSIONS AND RECOMMENDATIONS

The first year ratoon manured at the rate of 100 lb. nitrogen per acre, and cultivated and irrigated like the plant cane yields almost equally well as the plant cane, gives better juice quality, reduces cost of cultivation and is more profitable than even the plant cane. The older ratoons, because of their definitely low yields in spite of manuring and other care, give lower yields of cane and profits than plant cane. Incidence of insect pests, e.g., top borer, whitefly and stem borer is more in ratoons than in plant cane. *Pyrilla* and termite, however, tend to attack plant cane more than manured ratoons. On the whole, well cared for ratoons do not necessarily augment the pest trouble. Thus it may be concluded that ratooning for one year under average management, cultivation and manuring is a boon to growers as well as to the sugar industry. Longer ratoons than one year under the conditions prevailing in these parts of the country must be discouraged.

OBSERVATION ON THE STERILITY DISEASE OF PIGEON PEA*

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(With Plate XII)

STERILITY disease of pigeon pea (*Cajanus cajan* Millsp.) was first observed in Bihar in 1931 by Mitra [1931], who did not find any fungus in the tissue of diseased plants. Simultaneously, Su [1931] observed that the sterility of pigeon pea accompanied by a proliferaton of smaller leaves occurred with a greater intensity than in the previous year in Burma, but the cause of the disease was not known. Alam [1931] reported that the Sabour 2E '*rahar*' (*Cajanus cajan*) selection proved resistant to sterility, the incidence and severity of which varied considerably from year to year depending on external factors. McRae [1932] observed that crops grown from seed of plants with partial sterility did not show any difference either in growth characters or yield. He also reported that the disease could not be transmitted to healthy plants following inoculation by injection of juice obtained from leaves of pigeon pea showing partial sterility. Also, the occurrence of mosaic and 'little-leaf' of pigeon pea (*Cajanus indicus* Spreng) in 1937 at Coimbatore was reported by the Government Mycologist, Madras [Anonymous, 1938].

The disease was brought to the notice of the writer by Professor L. S. S. Kumar, Economic Botanist to Government of Bombay, in 1944. A survey of the district where pigeon pea is extensively cultivated in the Bombay State carried out during the winter season of 1946 showed that 'sterility' was present to the extent of about 7 per cent in general, while by January 1947 over 20 per cent of the pigeon pea plants cultivated for varietal selections at the Tobacco Breeding Station, Nadiad, North Gujarat, were affected by the disease. Diseased plants were mostly present in groups distributed all over the field which suggested that the disease was carried by some outside agency, probably insects.

The characteristic symptom expression of diseased plants and their presence in groups close to each other suggested that the disease is perhaps caused by a virus. Investigations on the disease with this possibility in view, were started in 1947, and the purpose of this paper is to report in some detail the results of these findings.

Symptoms

The symptoms of 'sterility' as observed under field conditions are essentially the same as those produced in artificially infected plants grown in glasshouses. Affected plants are palish green in colour and are characterised by upright and

* Paper read before the 37th Session of the Indian Science Congress held in January 1950 (*Proc. Indian Sci. Cong. Part* III, pp. 85 ; 1950.)

profuse vegetative growth. They are conspicuous by the absence of flowering branches rendering them 'sterile', although plants having both sterile and flowering shoots were frequently encountered. Leaves of diseased plants are generally reduced in size, are pale green in colour, and display a distinct mosaic pattern which may seldom be observed in older leaves. Under glasshouse conditions, the mosaic pattern is more distinct and conspicuous, and these symptoms persist for much longer periods (Plate XII, fig. 1). There is, however, no appreciable malformation of leaf lamina.

In a field, the diseased plants stand out distinctly from the normal plants which have deep green foliage and their branches drooping down owing to the weight of pods set on them. Younger plants when diseased are distinguished by general pallor and reduced leaves. But more often, it is difficult to read symptom expression in young plants under field conditions.

Transmission

Transmission trials by various means were made from time to time. Diseased material for graft inoculation had to be brought from Gujarat in suitably devised 'culture box' [Capoor, 1952]. Juice for transmission trials by leaf-rubbing was extracted from leaves of diseased plants by grinding them in a mortar with a little water or in 0·1 M Na_2HPO_4. The sap thus obtained was rubbed immediately after extraction over the young leaves of test plants, which had been previously dusted with carborundum powder of 600-mesh fineness. All inoculations were conducted on plants raised under insect proof glasshouses at Poona.

The disease was transmitted in about 49 per cent of the plants grafted with diseased scion. The failure of the remaining plants developing the disease was largely due to unsuccessful union between the scion and the stock. Pigeon pea is very susceptible to cutting, and is, therefore, a difficult plant to handle. The symptoms of disease in the form of typical mosaic mottle (Plate XII, fig. 4) invariably appeared in 35 to 40 days on pigeon pea plants inoculated with the 'sterility' disease by grafting. The suppression of flowering branches of the diseased plants was noticed after about 12 months following graft inoculation, when the controls of the same age grown under identical conditions had a normal flush of flowers and formation of pods in due course of time (Plate XII, fig. 2).

Out of 213 plants inoculated by the leaf rubbing method only 12 were infected. These plants developed a faint veinclearing on the younger leaves after about 10 days of inoculation, and the typical mosaic symptoms appeared on subsequently formed young leaves after 30 to 35 days. None of the remaining 201 plants kept under observation for more than 60 days showed the symptoms of the disease. The date of inoculation tests are set over in Table 1.

Although the virus was transmitted to comparatively more plants when inoculations were done with juice extracted in 0·1 M Na_2HPO_4 than on previous occasions (Table 1), yet the total number of successful transmissions was fairly low. Presumably, this was either owing to the virus being denatured very rapidly, or the test plants grown under normal conditions of light not being easy to infect by this method.

FIG. 1. (A) Healthy leaf, and (B) a leaf of diseased *Cajanus cajan* showing typical discolouration of leaflets

Photo : S. P. CAPOOR.

FIG. 2. *Cajanus cajan* (A) healthy and (B) graft infected 'sterile' plants of the same age. The healthy plant bears normal flowers and pods, while the diseased one produced only vegetative shoots. W, wedge-graft; F, flowers; P, pods

TABLE 1

Transmission trials with the 'sterility' disease of pigeon pea

Experiment	Date inoculated	Type of inoculation	*Cajanus cajan*	
			Plants inoculated	Plants diseased
A	January 29, 1947	Wedge-grafting	24	15
B	November 29, 1947	Do	12	5
C	January 20, 1948	Do.	24	2
D	December 29, 1948	Do.	15	12
E	November 1, 1949	Do.	10	8
F	March 19, 1949	Leaf-rubbing	22	1*
G	October 18, 1950	Do.	36	2
H	November 13, 1950	Do.	50	1
**I	September 24, 1951	Do.	45	3
**J	September 28, 1951	Do.	60	5

* Symptoms of disease appeared after 81 days.
** Juice extracted in 0·1 M Na_2HPO_4 and inoculated immediately after extraction.

Some sterile plants of *Cajanus cajan*, which were grafted in January 1947 and kept in the glasshouse, produced few flowering shoots in November 1950, after a lapse of nearly four years. This was an unusual phenomenon which has not been reported to occur elsewhere. The pods formed on these plants were collected and the seeds obtained from them were raised under insect-proof glasshouse to see if the disease was transmitted through them. Only 40 seeds were obtained, and sown on 8th September, 1951. All of them germinated and produced vigorously growing healthy plants ; which up to 155 days after germination did not show any symptoms of the disease. This confirms the observations made earlier by McRae [1932].

HOST RANGE

Plants of *Nicotiana tabacum* L. var. White Burley, *Datura inoxia* Mill., *Physalis peruviana* L., *Cyamopsis psoraloides* DC, and *Phaseolus vulgaris* L. inoculated with the juice extracted from diseased leaves of pigeon pea failed to give infection.

CONCLUSIONS

The symptom expression of the disease, its behaviour under field conditions as well as in the glasshouse, and the experimental evidence presented in this paper

are characteristic of a virus disease. The disease is readily transmitted by graft inoculation, but only in a few cases by the inoculation of juice extracted from leaves of diseased plants. It is proposed that the causal virus of the 'sterility' disease be called as the '*pigeon pea sterility mosaic*' virus.

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THE RELATION BETWEEN THE YIELD AND THE NUTRITIVE VALUE OF WHEAT

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IT is well-established that fertilization can increase the yield of a particular crop in a particular soil. Available information indicates that fertilization with a given mineral element increases its content in a specific crop in a specific location. More detailed experiments [Sheets, 1950] tend to show that such fertilization increases the content of one nutrient but decreases that of another. Even nitrogen fertilization which has by far the greatest effect on growth causes large reductions in calcium and iron content. Now the question arises whether or not a higher productivity caused naturally or through fertilization results in a higher nutrient level in a particular crop compared with that of the same type of crop when raised with a poor yield. From the point of view of overall nutrition this important problem of food and agriculture should be clarified particularly at this time of food shortage when attempts are being made in all directions to increase the food production. An unusually high yield of wheat [Munshi, 1951] (37 md. per acre) was reported recently in the press and this stimulated the desirability of determining the nutritive value of this particular crop when compared to that of an average standard. This paper reports the findings of this investigation.

Experimental

The sample of wheat which was procured just after the harvest was ground in a suitable laboratory mill until it passed a 40-mesh screen and was analysed for moisture, fat, total nitrogen, gluten, total minerals, fibre, carbohydrate (by difference) calcium, phosphorus and thiamine. Methods of A. O. A. C. were generally followed in all determinations. For thiamine, the thiochrome method of assay as modified by Hoffer *et al.* [1943] was followed.

The digestibility and biological value of the wheat proteins were determined by the nitrogen metabolism method developed by Mitchell and Carman in 1924 and 1926 taking weanling rats as the experimental animals. The determination of the metabolic fecal nitrogen per gram of food and of the minimum endogenous urinary nitrogen per W $\frac{3}{4}$ gm. was made in an initial and final period. The net utilization of the protein was then calculated by multiplying the digestive coefficients by the biological value and dividing by 100.

The growth-promoting value of the wheat protein was then compared with that of locally available wheat protein in an experiment with weanling litter-mate rats fed *ad lib.* amounts of diets containing equal sub-optimal amounts of protein (about 8 per cent) provided by the respective wheats, the protein being the factor limiting growth in an otherwise adequate diet. The protein efficiency ratio (weight increase in gm./gm. of protein consumed) was then calculated.

Results and discussion

The results of analysis for proximate constituents are shown in Table I below. For comparison the average composition of whole wheat [Kik an l Williams, 1945] is also given side by side.

Table I

Percentage chemical composition of the test wheat and that of an average wheat

	Test wheat	Average wheat
Moisture	11·12	11·2
Protein	12·21	11·1
Fat	1·65	1·7
Gluten	8·78	8·12
Ash	1·63	1·8
Fibre	2·2	2·4
Carbohydrate	71·19	71·8
Calcium	0·08	0·05
Phosphorus	0·27	0·40
Thiamine	5 micro gm./gm.	3·2—7.7 micro gm./gm.
Food value per 100 gm. (Calories)	348·0	347·0

Thus, so far the chemical composition is concerned the test wheat does not materially differ much with an average wheat. The test sample has a tendency to contain a little more protein but this difference is not significant because of the recognition that even a given variety of wheat can vary as much as 20 per cent in protein content according to the soil where it is produced [Maynard, 1950]. Though the ash content is almost the same in both the columns the test sample seems to be richer in calcium content but lower in phosphorus content. Whether this difference is due to the soil fertility or to genetic and/or climatic influence cannot be determined from this experiment. Amongst the vitamins, only thiamin has been determined. From the value as obtained in the test sample and when compared with average value one can reasonably say that the concentration of this vitamin has not been significantly influenced by the high productivity or high yield of the crop. It is interesting to find that though the yield is unusually high, the concentration of different nutrients has not been significantly changed and the total yield of nutrients per unit of land becomes unusually high along with high yield of the crop.

As cereal protein plays a significant role in our every day diet the nature of utilization of the protein in test sample was determined by growing rats. The

average value of the digestibility of the protein with due allowance for the metabolic fecal nitrogen and that of the biological value, representing the percentage of the absorbed nitrogen retained for maintenance and for growth are given in Table II.

TABLE II

Results of biological assay on wheat protein at 8 per cent protein level

Sample	Digestibility per cent	Biological value per cent	Net utilization per cent
Test sample	89·1	69·6	62·01
Average wheat	91·0	67·0	60·97

The figures in Table II indicate that the protein utilization of the test sample is identical with the average value obtained by different investigators.

The average experimental results regarding the growth supporting value of the proteins in test sample and the locally available wheat have been compared as shown in Table III.

TABLE III

Protein Efficiency Ratio (Weight gain in gm./gm. of protein consumed) when fed at 8 per cent protein level for 3 weeks

Sample	Food consumed gm.	Protein intake gm.	Weight gain gm.	Protein efficiency ratio
Test sample	142·0	11·36	24·5	2·16
Local sample	102·2	8·18	16·5	2·05

As the quantity of the test sample was not available sufficiently to continue feeding the animals for longer period, the growth study was made for three weeks only in place of the conventional period of 4 to 8 weeks resulting in a relatively higher protein efficiency ratio in both the cases. The results as obtained (Table III) with the test sample indicate clearly that the sample is in no way inferior to the average wheat in nutritive value. The growth study tends to show that on the same plane of protein intake, the animals on the proteins in test sample gained almost $1\frac{1}{2}$ times as much as those on the protein in market wheat. The efficiency of the proteins, however, when calculated from the food intake tends to be same in both the cases. It does not look like that the protein quality of the test sample has been changed by the influence of the productivity of the soil.

Summary

A sample of wheat was collected from a crop which was grown with an unusually high yield (37 md./acre). The nutritive value of this sample has been compared with an average wheat in order to find whether or not a high productivity results in a higher nutrient level. The chemical composition of the test sample does not materially differ much with an average wheat. The sample tends to contain a little more protein and calcium but a little less phosphorus ; the thiamine content has been found almost the same. Thus the concentration of different nutrients has not been significantly changed. The total out-turn of nutrients per unit of land is obviously high due to the high yield of the crop. The biological assay shows that the protein utilization, 'Protein Efficiency Ratio' or the protein quality has not been significantly changed due to high productivity.

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GRASSLAND RESEARCH

I. SOME PROMISING GRASSES AND LEGUMES AT THE INDIAN AGRICULTURAL RESEARCH INSTITUTE, NEW DELHI

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(Received for publication on 10 October, 1950)

(With Plates XIII—XIX)

THE value of grasses and legumes in practical agriculture has not been fully appreciated in India. The work on grasses has so far been restricted to only a few centres like Poona, Coimbatore and Sirsa, main importance being given to the fodder aspect. Equally important aspects viz., their role in soil conservation and in rotation with farm crops so as to maintain or improve the soil fertility, has hardly been touched. In the evolution of a permanent type of agriculture which takes into consideration the needs of man, animal and soil, the herbage crops, in the progressive countries, are being given great prominence. This is evident from the *Year Book of Agriculture* 1948 'Grass' published by U. S. Department of Agriculture, which is entirely devoted to the various aspects of grasses and legumes. Farmers are not unfamiliar with the fact that virgin soil when brought under cultivation remains highly productive for the first few years and gradually deteriorates under continuous cultivation. The most important change in the soil that is brought about by continuous ploughing, is in its structure on which depends the conditions of the air and moisture in the soil, which are indispensable for the healthy growth of a plant. The extensively developed fibrous root system of grasses brings about desirable changes in the soil structure, adds organic matter and thus increases the fertility of the soil. Roots are also helpful in holding the soil particles from being washed away and thus prevent erosion. When grown along with legumes not only a rich fodder is made available to farm animals, but also soil is enriched in essential plant food. It is in this broader perspective that the common grasses and legumes should be viewed by the farmers and interested workers.

Grasses and legumes are being studied from the above points of view at the Indian Agricultural Research Institute, New Delhi since 1947. Out of a collection of 70 different types of grasses and 40 legumes, 16 grasses and 18 legumes are described below : This constitutes the nucleus material and depending upon their useful agronomic characters, pointed out in the paper, the work on their exploitation for fodder, soil conservation and rotation purposes, is in progress. Many of these will be new to the farmers. Seed samples of these selected grasses and 12 legumes have been sent to different State Departments of Agriculture for trials under their soil and climatic conditions. The chemical analyses of the grasses and legumes referred to in this paper, was carried out in the Chemistry Division of this Institute, as part of the collaborative programme.

Kharif GRASSES

1. *Setaria palmaefolia* Stapf (*Bahpatia*)

This perennial grass has been collected from Assam where it is known as *Bahpatia*, means *bamboo* leaf (Plate XIII). It can be easily recognized by its bushy growth and broad, characteristic palm-like leaves. The grass is relished by cattle and is very nutritious, containing 16 per cent protein when cut before flowering and 10 per cent when in flowers (for fuller details refer to Table I).

The grass is well adapted to light soil of medium to high fertility such as is found in and around Delhi. On poor to medium soils, manuring with a mixture of $2\frac{1}{2}$ md. ammonium sulphate and 2 md. of superphosphate per acre shows a good response and should be repeated each year. The grass does particularly well under shade and should form a good material for improving natural grasslands.

The grass can be established by seeds or by rooted plants. When raised from seeds, the land should be thoroughly prepared and seeds broadcast or sown in rows $1\frac{1}{2}$ to 2 ft. apart, at the commencement of monsoon, at the rate of 2 pounds per acre. Weeding between lines is necessary during its establishment. The grass will be ready for cutting in three to four months time. While harvesting, particular care should be taken not to cut too low as the rooted branches get uprooted. The grass remains dormant during winter till beginning of monsoon. Vigorous growth is obtained in the second year. About 150 to 200 md. of green fodder can be obtained in one cutting. It is a profuse seeder and seeds can be collected during October-November. The grass, is however, afffected by frost.

2. *Plennisetum orientale* Rich (*Bimalsia*)

The grass was collected from Simla hills where it is known as *Bimalsia*. The grass in the general growth and nature of flower, resembles the common *anjan* grass (*Cenchrus ciliaris*) from which it can be readily distinguished by the larger and broader leaves and longer inflorescence. The grass is fairly nutritious containing about 8 per cent protein in the young stage and 5 per cent before and during flowering period. The grass grows well on light soils. Since the seed formation is rather low, it is better to establish the grass by rooted slips. About 15,000 rooted material will be required per acre. The grass will stand frequent cuttings as the recovery after each cut is quick. In this respect it compares favourably with Rhodes grass. The yield is fairly high and reaches about 350 to 400 md. in about 4 cuttings. The grass is particularly interesting as it shows an early, very leafy spring growth in February to March.

3. *Themeda anathera* Hack. (*Lunji*)

A collection from Kangra valley showing good promise under plains. The grass is related to common annual grass *Themeda triandra* (*Dhokla*, *Bhatadi* or *Fulghas*), but it is a tufty perennial and very thin stemmed. The latter quality makes it more palatable than the former. The grass is quite nutritious and contains about 5 per cent protein in young, preflowering and flowering stages. The grass can be established easily by seeds which are produced in large quantity. It is, however,

Setaria Palmaefolia Stapf (*Bahpatia*)

TABLE I

*Nutritive value of some promising grasses and legumes at Indian Agricultural Research Institute, New Delhi**

Name of grass or legume	Stage of analysis	Percentage of dry matter					
		Crude protein	N free extract	Crude fibre	Ether extract	CaO	P_2O_5
				Grasses			
1. Setaria palmaefolia	Preflowering	16·61	38·53	26·91	4·33	..	..
	Flowering	10·07	40·10	30·98	2·13	..	..
2. Pennisetum orientale	Young	8·65	42·41	24·15	3·75	1·19	0·55
	Preflowering	5·90	53·35	28·20	2·65	0·47	0·66
	Flowering	5·90	54·29	30·40	2·10	0·28	0·53
3. Themeda anathera	Young	5·61	47·02	28·72	3·95	0·48	0·39
	Preflowering	5·30	50·36	30·46	4·62	0·63	0·20
	Flowering	5·20	52·54	29·51	3·45	0·52	0·29
4. Panicum repens	Young	14·22	42·10	28·63	2·41	0·72	0·53
	Preflowering	4·39	53·73	32·02	1·65	0·48	0·41
	Flowering	3·63	50·93	32·57	1·77	0·26	0·29
5. Themeda tremula	Young (Average of 6, one monthly cuttings)	9·03	45·99	30·86	3·39	0·88	0·67
6. Chrysopogon montanus	Young	5·13	51·84	26·77	4·03	1·39	0·58
	Preflowering	4·61	51·63	32·57	3·53	0·79	0·58
	Flowering	4·01	52·24	33·36	2·56	0·93	0·21
7. Dichanthium annulatum	Young	5·26	53·26	28·50	2·73	0·59	0·41
	Preflowering	4·20	53·36	29·01	2·37	0·92	0·33
	Flowering	5·23	55·56	26·65	3·11	0·80	0·38
8. Heteropogen contortus	Young	7·52	49·51	28·87	3·25	0·95	0·40
	Preflowering	4·40	56·83	26·90	3·17	0·46	0·32
	Flowering	2·35	58·58	28·89	2·46	0·34	0·37
9. Sehima nervosum	Young	7·83	39·99	29·80	4·35	0·86	0·29
	Preflowering	8·63	39·09	34·21	3·40	0·80	0·44
	Flowering	2·54	48·47	36·16	2·66	0·72	0·16
10. Cenchrus ciliaris	Young	5·30	49·63	22·85	2·71	1·11	0·83
	Preflowering	11·88	45·16	24·82	4·54	0·80	0·95
	Flowering	11·87	46·62	28·99	1·12	0·73	0·85
11. Cenchrus setigerus	Young	9·57	47·75	26·55	3·75	0·60	0·57
	Preflowering	8·07	45·46	..	..	..	..
	Flowering	7·31	47·59	31·12	2·33	0·42	0·52
12. Phalaris minor	Young	19·04	38·50	21·24	3·72	1·30	0·89
	Flowering	13·93	31·32	39·90	5·18	0·72	0·55
				Legumes			
13. Vicia hirsuta	..	37·91	21·37	19·76	2·34	3·03	1·21

* Analysed by shri M. A. Idnani and his co-workers

slow to establish, making a good growth in second and the following years, about 3 cuttings yielding about 250 md. per acre can be obtained in the first year. It can make a very useful hay crop. The grass is particularly suitable for introducing in natural grasslands where annual *Themeda's* are dominant.

4. *Panicum repens* Linn. (*Silckoo*)

This grass was originally collected from Coonoor. It is specially suitable for sandy soils where it makes a very rapid growth. The grass is very aggressive and quickly invades adjoining areas. It propagates by underground runners and hence is a very suitable material for control of erosion. There are huge tracts in the plains of Northern India where severe erosion has taken place owing to unrestricted grazing and the soil has become very loose and unretentive of moisture. It is well worth to try this grass in these tracts. The growth is very vigorous during summer months and completely covers the soil surface. The grass is palatable and very rich in the young stage containing 14 per cent protein, but protein content falls rapidly as it advances in age. The grass can be established either by seeds which may be broadcast or better, by rooted runners during monsoon. The grass, however, should not be introduced in fields which are meant for cultivation as it is difficult to eradicate by ordinary methods. It gives a fairly high amount of palatable fodder of about 120 md. per acre, per cutting giving about 4 cuttings during the year.

5. *Panicum antidotale* Retz. (*Bansi*)

A very drought resistant perennial grass (Plate XIV, fig. 1) obtained from Karnal. The grass is highly nutritive and figures quoted elsewhere show that it is one of the richest fodder grasses. The grass remains green throughout the year giving out new shoots continuously if the winter is not very severe. The soil requirements do not appear to be very exacting and the grass can grow on poor light soils. It can be easily established by seeds and about two pounds seed will be required per acre. The seeds can be broadcast or sown in lines before the commencement of monsoon. With the first shower, seeds will germinate and will provide fodder in about three months time. It can stand number of cuttings and each time the recovery is very quick giving about 90 md. per cutting. Under sewage conditions it yielded 950 md. in 5 cuttings. The grass should not be allowed to grow in height as it then becomes very coarse and unpalatable. It is desirable to cut as soon as the flower bearing shoots come out. In the drier tracts the grass should show great promise.

6. *Themeda tremula* Hack. (*Giant Dhokla*)

This came to our collection from Bijapur. It is a very robust perennial grass growing to a height of 6 to 7 feet and with a very large number of tillers. The grass is fairly rich in nutritive value containing about 9 per cent protein in pasteur stage. It is fairly quickly established on light soils of low to medium fertility. The grass does not produce lot of seeds and therefore quicker method of its establishment is by transplanting rooted slips. The grass recovers very quickly after each cutting and the new growth is very leafy, like Rhodes grass. It is expected to yield over 400 to 500 md. per acre in about 4-5 cuttings.

FIG. 1. *Panicum antidotale* Retz. (Bansi)

FIG. 2. *Phalaris minor* Retz. (*Chidia Bajra*)

7. *Chrysopogon montanus* Trin. (*Dhawalu*)

This is a well known grass fairly distributed all over the country on hills as well as on plains. It is known as *dhawalu* based upon the white inflorescence. It is relished by cattle and is fairly nutritious containing about 5 per cent protein in the young and 4·6 per cent in the preflowering stage. The grass is fairly drought resistant and grows well in light soils. The grass can be easily established by seeds and should be sown in rows 2 ft. apart. The distance between plants should be 2 ft. It is necessary that the grass be cut before flowering, as later on, it becomes woody and less palatable. It gives about 120 md. per cutting and about 3 cuttings can be had. In the collections of this grass two types have been met with ; one showing early leafy spring growth during March to April. In the other variety which was obtained from Nagpur the growing season is chiefly restricted to monsoon. Wherever possible mixture of these two would prove advantageous.

8. *Dichanthium annulatum* Stapf. (*Apang, Marvel*)

This is the common *apang* grass of Delhi tract and is known fairly well throughout the country under different local names. It is considered to be a first class grass in all parts of India. It is readily recognized by the presence of a hairy ring on the node and a cluster of 4 or more scarlet coloured earheads. It is very palatable and contains about 5 per cent protein. It also makes a very fine hay. The grass is suitable for both light and heavy well drained soils. The grass can be established by seeds or rooted plants during monsoon. It is rather difficult to collect seeds which ripen at different periods. Hand picking of the seed is therefore the best method. The first cutting can be taken in October to November. The growth in the spring is comparatively early but does not contain sufficient leafy material. Regular cuttings can be taken up from the second season. 3 to 4 cuttings are possible giving a bulk of over 400 md. During its second growing season at the Indian Agricultural Research Institute it has given 600 md. in 4 cuttings. We have under observation several collections of this grass and a strain from Karnal has been found superior in respect of its growth and has been selected for cultivation. Varieties of this grass suitable for grazing have also been selected. This form makes a more creeping growth. The grass makes a fine mixture with *Lucerne* and *Vicia hirsuta*, legumes which increase the nutritive value of the fodder.

9. *Heteropogon contortus* Roem. (*Surbala, Kusal*)

This is the well known 'spear grass' of India. It is locally called *surbala* perhaps based upon the resemblance of the twisted spear to stiff hairs of the wild boar. The grass is very much relished by the cattle before the spears are formed and again after they have dropped down. The grass is fairly rich in young stage when it contains 7 per cent protein, there is 4 per cent protein in the preflowering stage and contains 2 per cent protein in the flowering stage and therefore should be grazed or cut before the flowering stage. The grass can be established by seeds or rooted slips. Out of several collections of this grass under observation we have selected one from Guna, Gwalior which is very leafy and tillers profusely. The spear formation is also comparatively late. The grass yields about 90 md. per acre per cutting and 2 to 3 cuttings are possible.

10. *Sehima nervosum* Stapf. (*Paonia*)

This is the well known grass of Madhya Pradesh and is locally called as *paonia*. It can be readily recognized by the tapering long leaf and single spike with zigzag black margin. It is very leafy and shows a bushy growth. It contains about 8 per cent protein in preflowering stage ; the protein content drops down to 2·5 per cent in flowering stage and therefore should be best utilized before flowering. It can be established by seed. The yield is fairly high and about 400 md. of green fodder can be obtained in three cuttings.

11. *Cenchrus ciliari* Linn. (*Anjan*)

The well known *anjan* grass of Punjab and other drier tracts. The grass is well recognized as a very palatable and highly nutritious grass, containing about 11 per cent protein in preflowering stage which is maintained during flowering stage. Unlike other grasses described above this grass however shows a poor spring growth and therefore, is essentially a monsoon grass. It can be easily established by seed and yields about 400 md. of green fodder in 3 to 4 cuttings.

12. *Cenchrus setigerus* Vahl. (*Anjan*)

The grass closely resembles the one described above and occurs in close association with it. It can be readily recognized by the presence of black inflorescences which are hard to the touch. The inflorescence in the other species is white and soft. The grass is more robust than the above, the grass is less nutritious than the above and contains 9 per cent protein in preflowering stage which drops down to 7 per cent in flowering stage. Like the above grass it can be established easily by seeds. Out of several collections a collection from Ajmer has been found to make a better growth. The yield is about 400 md. in 3 to 4 cuttings. This grass also shows a poor spring growth.

13. *Chloris gayana* Kunth. (*Rhodes grass*)

A grass originally from South Africa was introduced in the country very early. The grass can be recognized by the presence of flattened stems at the base and a bunch of greenish spikes at the top. Trials conducted in the country have shown that the grass is particularly suited to light well drained soil and our experience has been that it is one of the best grasses suitable for Delhi and round about tracts. It is very leafy, and shows a remarkable quality of a very quick recovery after each cutting. Within 4 to 5 weeks the grass is generally ready. The new growth is again very leafy. In this way several cuttings are possible. The grass is relished by the cattle and a yield of over 500 md. in 4 to 5 cuttings can be obtained. In our trial at Delhi we have been able to grow it in mixture with *Lucerne* for more than three years. Owing to the presence of *Lucerne* the quality of the fodder has been considerably improved. The grass is not only suitable for feeding green, but also is very fine for grazing. The grass is fairly aggressive and quickly covers the soil by its surface runners during summer. The grass is fairly resistant to cold and drought. The seed collection, although laborious, is within practical means and quite a large quantity can be secured by hand picking. Because of the difficulty of obtaining

FIG. 1. *Lolium rigidum* Gaud. (Wimmera Rye grass)

FIG. 2. *Phalaris tuberosa* Linn.

seed, the grass is usually propagated by rooted runners. If any seed merchant takes up the supply of seed, for which there is fairly good demand, spread will be quicker. For better yields the grass should be manured with a mixture of $3\frac{1}{2}$ md. of ammonium sulphate and $1\frac{1}{2}$ md. of superphosphate each year.

Rabi Grasses

14. *Phalaris minor* Retz. (*Chidia Bajra*)

The winter annual grass, seen growing naturally in a field of oats in the sewage area of the Farm, attracted attention by its luxuriant leafy growth and by the possibilities of using it as a valuable fodder during the *rabi* season when the common grasses listed above remain dormant. The grass is known locally as *Chidia bajra*, (Plate XIV, fig. 2). In general habit of growth in early period it resembles the oats plant. It is very rich in nutritive quality containing 19 per cent protein in young and 13 per cent in flowering stage. It is very palatable before flowering and the dairy animals readily consume it. It prefers soils of medium to high fertility and moist conditions. The grass seeds profusely. For cultivating the grass, land preparation should be thorough and seeds should be either broadcast or sown in lines 1 to $1\frac{1}{2}$ ft. apart, in October to November at the rate of 6-8 lb. per acre. The crop is ready for harvest in middle of February. If cut early in February, a second cutting is obtained by the middle of March. It is quite a good yielder and about 200 md. of palatable green fodder can be obtained. The grass can be successfully grown in combination with *senji* (*Melilotus parviflora*) and *akra* or *chatri matari* (*Vicia hirsuta*).

15. *Lolium rigidum* Gaud. (*Wimmera Rye grass*)

Rye grasses have been recognized in other countries as very valuable fodders. Wimmera rye grass (Plate XV, fig. 1) first attracted the attention in Australia from which country its seed was obtained. The grass is recognized as a high yielding, very palatable grass showing the quality of self-regeneration. The grass is a winter annual and has shown promise under Delhi conditions. The grass can be established by seed which should be sown in October to November and is ready for cutting in late March or beginning of April. The grass prefers soils of medium to high fertility and appears to be fairly drought resistant.

16. *Phalaris tuberosa* Linn.

Phalaris tuberosa (Plate XV, fig. 2) is a winter growing perennial grass and has been extensively used in Australia for cultivated pastures. Experiments conducted in Australia show that it does well under both heavy and light soils especially so on soils of high fertility. Seeds of this grass were obtained from Australia. The growth under Delhi conditions was very profuse and in one cutting it gave a yield of 165 md. per acre. The grass showed a much healthier growth during winter when sown in August. The plants from October to November sowing did not show marked growth. The grass persisted even in the second season thus indicating its perennial habit. The grass is promising and needs further trials. Seed formation

is rather poor as compared to the local species. For seed formation it should be tried in the hills.

Legumes

Legumes are essential in any programme of fodder improvement. The legumes grow well in association with grasses. They are rich in protein value and therefore the mixture of grasses and legumes provides a richer fodder than when grasses are grown alone. The legumes can also be grown alone for fodder or green manuring. The following legumes have been found to do well under Delhi conditions.

Winter legumes

Winter legumes for fodder or green manuring are only few and there is thus good scope for finding new plants suitable particularly for the drier tracts where the fields remain generally bare of any crop. In our collection some of the legumes described below show promise of growing in these tracts.

Vetches (*Vicia* species)

Vetches are being largely used in other countries as cover crops, fodder, green manuring or growing in mixtures with grasses. The plants resemble gram plants in general growth and behave in the same way with regard to soil and water conditions. The collection at the Indian Agricultural Research Institute comprises of 8 different types from different parts of the world ; all of them have shown promise for one or the other purpose.

Vicia hirsuta Koch.

This is a local collection and is fairly well distributed in the country both in wheat and rice tracts and is commonly known as *akra* or *chatri-matari* (Plate XVI, fig. 1). It is considered as a weed of cultivation. Weed seeds generally remain dormant during the unfavourable season and germinate as soon as the conditions become favourable and grow very vigorously even though unattended . This is exactly the quality of this weed that should be exploited. *V. hirsuta* forms an excellent fodder containing a very high percentage of protein to the extent of 37 per cent, grows naturally under rainfed conditions and covers the soil completely. The growth can either be cut, grazed or ploughed in to serve as green manure ; it, therefore, deserves a favourable consideration by practical farmers.

For fodder it is better to sow it along with oats or *Phalaris minor* with which it makes an excellent combination. The seed rate of *vicia* in combination should be about 40 lb. per acre, oats or *Phalaris* being sown at the rate of 60 lb. and 6 to 8 lb. respectively. When sown in November the fodder will be ready for cutting in February to March, giving about 200 md. per acre of very nutritious green fodder. This combination would be found suitable in rice tracts where generally the fields remain bare after the harvest of paddy till the next sowing. In the natural grasslands, introduction of this plant will provide a winter grazing which normally is not available.

FIG. 1. *Vicia hirsuta* Koch.

FIG. 2. *Vicia atropurpurea* Desf.

FIG. 1. *Vicea villosa* Roth.

FIG. 2. Medicago hispida Gaertn. (Bur clover)

Other vetches. The promise shown by *Vicia hirsuta* initiated the collection of other species of this group. The following species have been found to show better growth than the local vetch and are under preliminary observations.

Vicia autropurpurea Desf. (*Purple vetch*). This vetch (Plate XVI, fig. 2) has been very highly spoken of in Australia where it is used extensively for fodder and green manuring purposes. The vetch showed a very vigorous growth under Delhi conditions and reached a height of about 2 ft. The seed formation, however, is very poor. If soil and climatic requirements suitable for seed formation could be found out, this vetch would serve a very useful function in the rice and wheat tracts under non-irrigated conditions. The growing period is from November to March and it can be cut at least twice.

Vicia villosa Roth. (*Hairy vetch*). This vetch (PlateXVII, fig. 1) is being largely used in the U. S. A. as winter cover crop for protecting the soil from erosion, for fodder or green manuring purposes. The growth under Delhi conditions was excellent and completely covered the plot. The growth at first is very slow and is mainly restricted to covering the soil surface very closely. With spring, the optimum growth period commences in March and soon completely covers the soil and makes a sufficient top growth to take a cutting. The vetch remains green throughout April and even extends into early May. Flowering is very erratic. It did not flower in 1949 but flowering was profuse in 1950, and pod formation was medium. This vetch like the Purple vetch has also a promising future in the tracts mentioned above, provided the problem of seed formation is solved. A variety of this species from Uruguay has shown better seed formation than the U. S. A. variety but the growth was not as prolific as in the other variety.

Vicia sativa Linn. (*Common vetch*). Seeds of this species was obtained from Cyprus. The plant showed a much better growth than the local species. It is a late species compared to the local type and remained green throughout March. Quicker multiplication of this species is possible as the seed formation is excellent. It yielded 300 md. of fodder in one final cutting.

Vicia ervilia Willd. (*Bitter vetch*). Seeds of this species were also obtained from Cyprus. Unlike the species described above the plants do not show a tendency of climbing and showed more or less tufty growth. The pod formation is also excellent. It yielded 150 md. of green fodder per acre in one cutting.

Vicia benghalensis Linn. and *V. naturalizada.* These two vetches, seeds of which were obtained from Uruguay have also shown promise as the growth is better than the local species ; pod formation is fairly good and it remains green till the ends of March.

Sydney vetch. This vetch was obtained from Sydney. The growth was better than the local variety. The pod formation was fairly good. In general appearance it resembled the local vetch.

Medicago (*Medicago* species)

Medicago is that group of legumes to which Lucerne (*Medicago sativa*) belongs. In the lawns in Delhi, Agra and other near about places, local *Medicago* appear by

self seeding during winter. These plants are fairly drought resistant and provide a very palatable and nutritious fodder. Besides collection of Lucerne which is perennial and which is fairly known in the country, we have some annual medics, two of which appear promising.

Medicago hispida Gaertn. (*Bur clover*). Seed of this plant was obtained from the U. S. A. The plants showed very vigorous growth (Plate XVII, fig 2), particularly with the approach of spring in early March and in the preliminary tests had given three cuttings; each time the recovery was very rapid. In this way about 250 md. of fodder can be obtained. The seed formation is excellent and if allowed to drop, the plants come up in November to December automatically and behave like the local vetch. The plant dries up in mid-April. In the drier tracts this plant is expected to show good promise.

Medicago denticulata Willd. (*Barrel clover*). This plant is similar to above in general growth characters. Seeds of this species were obtained from Australia. It differs from the above plant in the nature of the fruit. The fruits do not show long brittle hairs as in *M. hispida* but the fruit surface is slightly toothed.

Sweet clovers (*Melilotus* species)

Sweet clovers have been much in use in the U. S. A. for pasture and green manuring purposes. These plants resemble the well known local fodder *senji* (*Melilotus parviflora* Desf.) with yellow flowers from which they differ in having white flowers. A variety of this clover known as *Hubam clover* (*Melilotus alba*) Lam. (Plate XVIII, fig. 1) in the U. S. A. has been found to do exceptionally well under Delhi condition. The plants in general reach a height of over 5 ft. and show maximum growth during March to April and remain green throughout May. The common *senji* is generally ready for cutting in late February at a period when the active growth in *Hubam clover* just commences. By sowing a mixture of *senji* and Hubam clover at optimum seed rates, it is thus possible to continue the provision of fodder till May. *Senji* is fairly drought resistant and so is *Hubam clover* and hence its introduction in the drier tracts should prove of great advantage. It gives very high yields and about 150 md. of green palatable fodder can be obtained in one cut and about 3 cuttings are possible. A perennial variety of this clover known as '*Ever green sweet clover*' was also under observation. It maintained its perennial habit but the growth was not very marked.

Lupins (*Lupinus* species)

Lupins (Plate XVIII, fig. 2) are well recognized in temperate countries as an excellent material for green manuring. These are generally bitter in taste and contain poisonous substances. Sweet and non-poisonous types are also available but they did not show good performance under Delhi conditions. There are two species, one with blue flowers known as Blue lupins and the other having very beautiful yellow flowers known as yellow lupins. blue lupins showed a heavy growth, plants reaching a height of $3\frac{1}{2}$ feet. The yellow one is a dwarf variety. When sown in November the crop can be ploughed in the beginning of March.

FIG. 1. *Melilotus alba* (Hubam clover)

FIG. 2. Lupins (*Lupinus* species)

Lathyrus sativus. Linn.

Lathyrus sativus, locally known as *khesari* is a fairly recognized legume, and is used to a certain extent as a green manuring plant. It generally grows along with *Vicia hirsuta* in the paddy fields and is fairly drought resistant. Seeds of this legume are sometimes eaten as famine food by poor people. The seeds possess certain poisonous properties which induces the so-called Lathyrism and paralyses the body. The legume, however, could best be used as a fodder when just in flowers or can be used for green manuring. A collection obtained from Egypt showed a very vigorous growth and it was possible to take one cut; the fresh growth is fairly rapid and would thus be available for ploughing in. The pods are bigger and develop profusely in this collection.

Methra (*Trigonella foenum-graecum* Linn.)

Methra is a commonly recognized fodder in the Northern tracts yielding about 200 md. of green fodder per acre. The plants are fairly drought resistant and therefore they deserve more attention in the rainfed area.

Kharif legumes

Legumes like cowpeas, *guar*, *wal* are usually grown. In our collection the following new legumes have shown promise either for growing in mixture with grasses or alone.

Desmodium diffusum D.C. *Desmodiums* have attracted attention recently in the tropical countries for the improvement of fodder and grasslands. *Desmodium diffusum*, an annual legume, locally called *ratanmala* because of the beaded pods, commonly grows in grasslands, more particularly on black soils. The plant showed good promise on the light soil of the Farm for introducing in the mixture. The plants show a very characteristic growth and cover the soil completely in a short period by its trailing shoots which radiate in all directions. The fodder is very palatable.

Alysicarpus rugosus D.C. (*Shevari*). This is another annual species, which is fairly common throughout the country and is recognized as a good fodder. Its mixture with the grasses, tried at certain places in the country have achieved good results and our experience also has been the same. The legume forms a good mixture with *Dichanthium annulatum*, (*apang*), Rhodes grass and *anjan grasses.*

American soybeans-Glycine max. Soybeans are growing in importance both as a human and cattle food. The plants show a very high content of protein. A very highly nutritive product of soybean known as Soya milk is prepared out of the seeds. It is an excellent fodder and is generally sown mixed with maize, *jower* and Sudan grass. The common varieties viz. yellow, black and chocolate, selected at Pusa are very late maturing and take about 5 to 6 months for grains and about 4 months for fodder. The American varieties of soybeans at Delhi, are very early maturing and are ready for grain in about 2 months time and in about 45 days for fodder. Thus when sown in August, the crop can be harvested for grain in early October. Out of 24 varieties in the collection 5 have been found to possess better growth and are under study. These are Palmetto, Clemson, Monetta, Creole and

Charlee. The grain is bolder than the local varieties and grain yield of about 10 md. per acre can be had. If cut for fodder, about 150 md. of very highly nutritious fodder could be obtained.

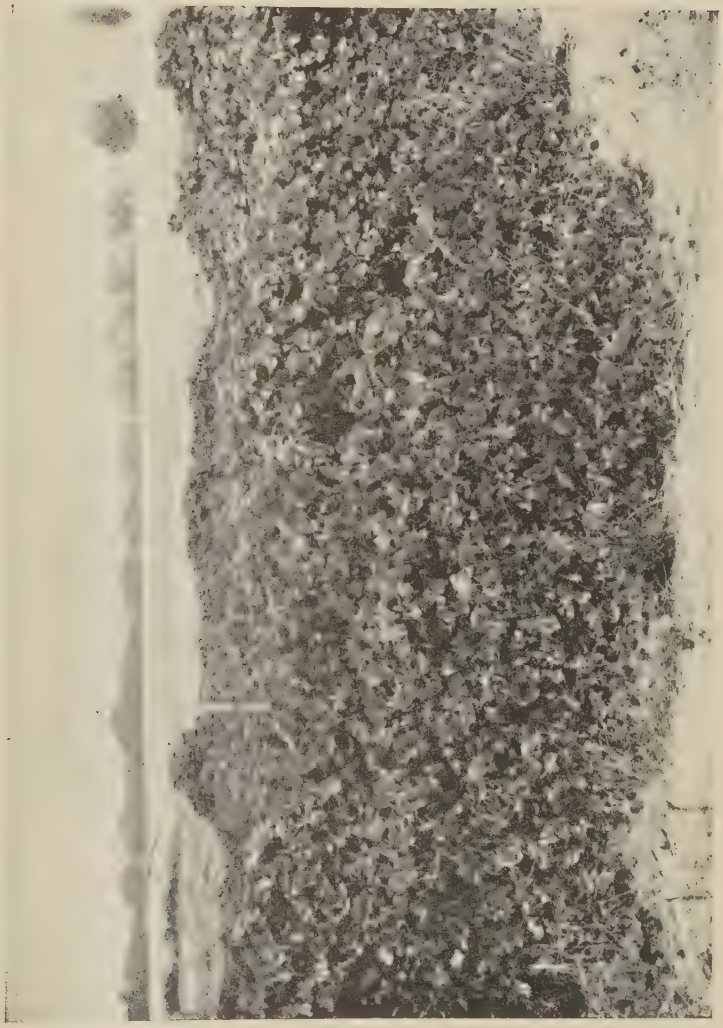
The earliness of these varieties is a character which can be used very profitably. For example, in the rainfed tracts where wheat is taken, the farmers generally keep the land fallow during the *kharif* season. These early maturing soybeans can very profitably be used as a catch crop in rotation with wheat. The crop can be sown in July at the commencement of monsoon and cut for fodder late in August or can be ploughed in middle of August or can be taken for grain early in September giving sufficient time for its decomposition as well as for the preparation of land for wheat. These varieties are affected by frost but in frost free regions like the coastal regions where the climate is equitable, these varieties could be sown almost any time during the year, for grain or green manuring for paddy crops.

For growing the crop the land should be manured with superphosphate at the rate of 200 to 250 lb. per acre. The seed can be drilled in rows from 1 to 1½ ft. apart at the rate of 16 lb. for grain and 32 lb. for fodder. Under Delhi conditions early August sowings have given good results. The sowing date, however, can be adjusted. In grain yield palmetto outyielded other varieties in a trial at the Institute.

Kudzu vine (*Pueraria hirsuta* Scheid Syn. *P. thunbergiana*)

Kudzu vine (Plate XIX) has been very largely used in the U. S. A as a fodder cum-soil-conservation crop. The plant was first introduced in India at Pusa in 1925 and has shown good promise as a fodder. The propagation, however, was restricted to only some research centres, owing to absence of seed formation. The possibility of its wide spread propagation has only recently become possible with the formation of seed at the Institute. A plant planted in 1945 flowered and formed seed for the first time after three years. The seed setting at first scanty increased in 1949-50 and gave about 325 seeds. The plant has a very vigorous growth habit and sends out trailing shoots in all directions and rapidly covers the soil. It remains dormant during winter and puts forth vigorous growth in March with the approach of spring and continues to grow throughout summer and monsoon months till October to November when with the first lowering in temperature the leaves wither and die. Thus each year a large amount of organic material is added to the soil, and enriches it. The growth in each spring is more vigorous than in previous years and encroachment is rapid. A plant obtained from Poona and planted in 1945 has made such a rapid progress that at the end of 1949 it covered an area of 4,000 square feet.

The vine makes an excellent growth on light soil of poor fertility. The areas suitable for successful introduction of this vine, are the northwest drier tracts which have been subjected to very serious type of erosion and a vigorous growing plant like Kudzu vine can reclaim the area thoroughly and quickly. Protection from grazing is needed for at least two years; thereafter moderate grazing will not affect the stand. Since the vine remains green during summer months, it will provide



Kudzu Vine

an excellent pasturage to the hungry cattle of the tract. A four year stand of the vine at the Institute yielded 450 md. of green fodder in three cuttings.

The vine is generally propagated by vegetative methods rooted cuttings or layerings. The former method has not been found satisfactory. Our experience has been that the crowns, which make fresh growth during March, if dug out and transplanted in nursery for planting in monsoon, ensures the surety of the stand. Now since seed formation has become possible, the propagation is expected to be easy. Before sowing, the seed requires some preliminary treatment to soften the hard seed coat; mechanical scarification with sand paper has given good results at the Institute.

Kudzu vine is a wonder plant, with a great potentiality for improving the fodder resources of the tracts mentioned above. It is for the farmers and others interested in the welfare of the farmers to make a sustained effort to achieve this objective.

ACKNOWLEDGMENTS

Our grateful thanks are due to Dr J. N. Mukherjee, Director, Indian Agricultural Research Institute at whose initiation this line of study was started at the Institute; we also express our grateful thanks to Dr T.J. Mirchandani, Head of the Division of Agronomy; both of them took great interest in this work and encouraged the preparation of this paper. We acknowledge with thanks the help of Mr. S. Sen for the initial grass collection; to various State Agriculture and Forest Department for their co-operation; to Dr B. P. Pal, Head of Division of Botany for supplying us with various plant material through Plant Introduction Section.

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OPERATING COSTS OF A FARM TRACTOR AT KARNAL.

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(Received for publication on 3 September, 1951)

(With Plates XX-XXI and two text-figures)

ONE of the biggest items in arable farming is that of machinery and equipment. The present national situation, wherein the farmer is being asked to produce more, makes it even more important that farm equipment be used with maximum efficiency. A farmer should analyse his costs and predict future reductions in the working and selection of equipment for his particular situation. It must, however, be remembered that good machinery alone will not make a farmer successful if he is poor with the husbandry of crops, but an unwise machinery performance can bankrupt almost any farmer however skilled he may be in other lines.

Table I

Summary of work done

Serial Number	Operations	Hours	Acres	Acres per hour	Cost per acre
1	Ploughing	765·00	949·56	1·25	3·39
2	Harrow ploughing	1829·25	4492·48	2·46	1·84
3	Disc-harrowing	1867·02	4657·98	2·42	1·73
4	Grubbing	2386·02	7061·97	2·96	1·44
5	Drilling	39·75	105·27	2·90	1·64
6	Rolling	2·50	11·50	4·60	0·72
7	Combined disc with grubber	27·75	66·49	3·00	1·72
8	Reaping	3·50	4·50	1·29	3·56*
9	Belt work transport etc.	1928·16	..	..	..

* High due to light machine being used.

In Tables I and II are given details of the working costs of one W. D. 40 McCormick Deering Diesel Tractor No. 1612 and are also graphically represented in figs. 1 and 2. The tractor was purchased in 1936 for Rs. 7,152-8 f.o.r. Karnal. It was kept regularly in work for 10 years until 1946 by which time it had passed the stage of effecting service and economic repair. The makers estimated the working life of these tractors to be 8,000 hours.

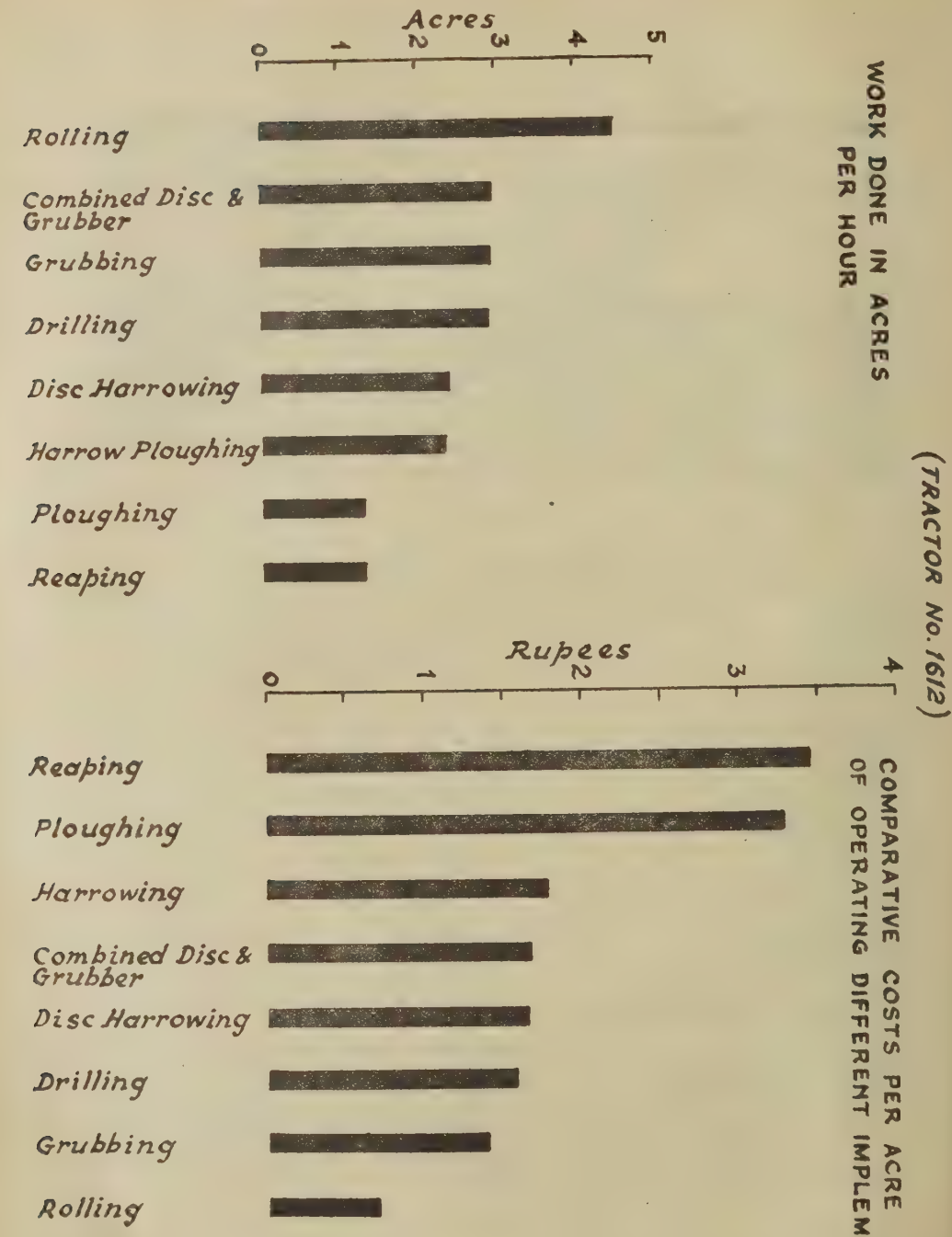
WORK DONE IN ACRES PER HOUR
(TRACTOR No. 1612)
Acres
0
1
2
3
4
5
Rolling
Combined Disc & Grubber
Grubbing
Drilling
Disc Harrowing
Harrow Ploughing
Ploughing
Reaping
COMPARATIVE COSTS PER ACRE OF OPERATING DIFFERENT IMPLEMENTS
Rupees
0
1
2
3
4
Reaping
Ploughing
Harrowing
Combined Disc & Grubber
Disc Harrowing
Drilling
Grubbing
Rolling

FIG. 1.

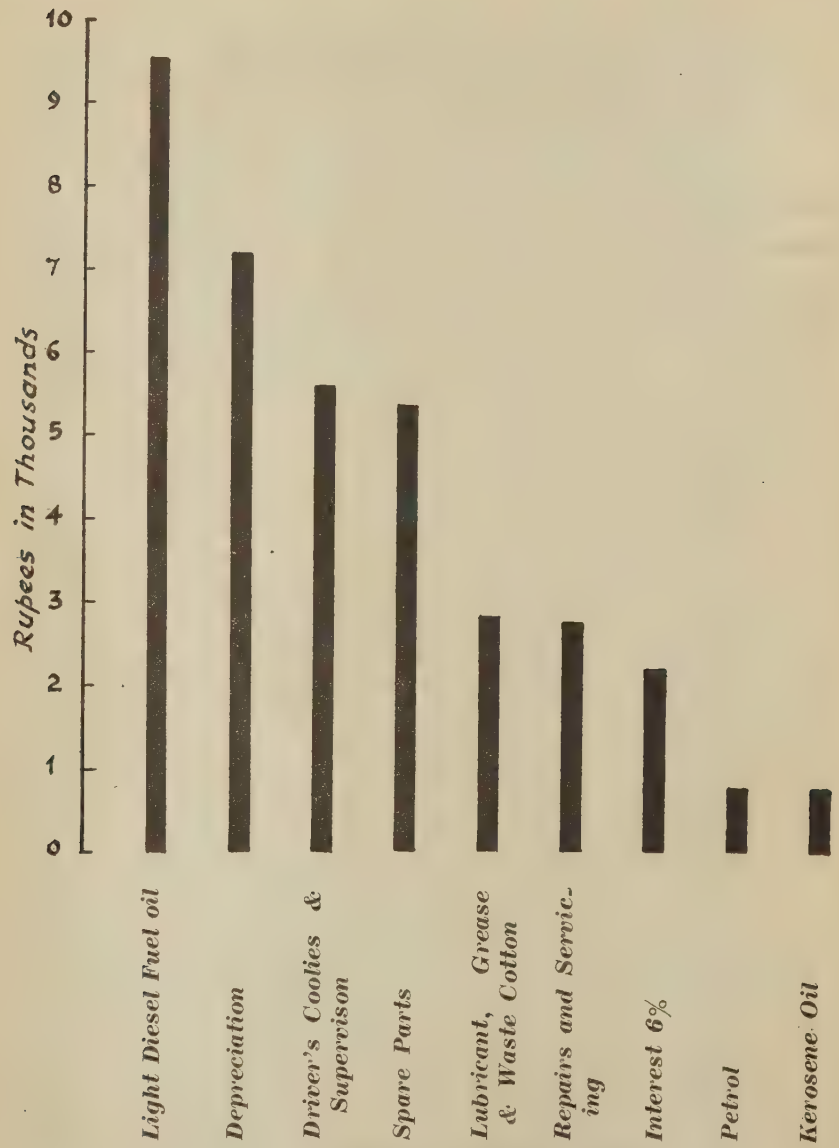

FIG. 2.—Comparative cost of different items for lifetime of tractor No. 1612.

TABLE II

Analysis of total cost of Tractor No. 1612

—	Total	Per cent of total cost
Light Diesel Oil	9437·53	25·64
Kerosene oil	562·31	1·53
Petrol	604·79	1·64
Lubricant, grease and waste	3209·24	8·72
Labour	5416·26	14·72
Repairs and servicing	3009·17	8·18
Spare parts	5365·26	14·58
Depreciation	7152·50	19·43
Interest at 6 per cent	2045·15	5·56
Total	36802·21	100·00

It will be seen that No. 1612 actually operated 8849·07 hours. The tractor operated during the war period during which, particularly in the latter half, spare parts were not only expensive but extremely difficult to procure.

The farm area was not originally laid out for large scale tractor operations and consisted of small and large size fields of various shapes bound by irrigation channels which often necessitated much loss of time and repetition on short work. The area also included a considerable amount of land which had been out of cultivation for a number of years and had to be broken up and brought back into cultivation. These factors operated amongst others to cause variation in the acreage per hour worked and the cost per acre.

The soil of the area, worked varied from light loam—medium loam to clay loam—having about 33 per cent in each category.

The area was mostly double cropped and farmed on mixed farming lines to provide fodder crop as roughage for the Pedigree Tharparkar herd of cattle and also concentrates in the form of cereals and pulses grains both in the *kharif* and *rabi*. *Rabi* cereals entailed generally the following cultivations :

Ploughings 1 or 2, 2 discings and 2 grubbings, (cultivator). The *kharif* crop required half this number of cultivations, usually though ploughing at this season could often be dispensed with and the whole operation done by the harrow plough or grubber and disc-harrow owing to the fields being freer of weeds at this season. The number of cultivations varied considerably with the season and from field to

A combination of 3 seed-drills.
Area sown per hour—5·10 acres.

A combination of village implements for preparing seed bed in one operation.
Area covered—3·5 acres per hour

field depending on the prevalence of weeds and the luck of the weather. In years of well distributed rainfall operations were maximum in their effectiveness in both weed control and in tilth production. Heavy and ill distributed rain tends to keep tractors off the land for considerable periods particularly on the heavier loam when excessive weed growth makes subsequent work both difficult and slow.

As the implements were not purchased for specific use with this tractor and during the war others adopted to the power of the tractor were not available, the tractor could not always be operated up to full load. As a partial remedy to this, efforts were made to combine tandemwise various implements such as disc-harrow and grubber (cultivator) in one unit (Plate XX). Such arrangements are, at the best, merely make-shift and cannot be wholly satisfactory. Cultivating implements are made to function for specific soil conditions, it cannot therefore often occur that the soil is just in the right condition for work with a grubber and at the same time just right for an implement so different in effect as the disc-harrow. The result in the circumstances is usually a poor compromise (Plate XXI).

Success in mechanised cultivation presupposes a high standard of mechanical skill on the part of the operators and considerable aptitude for the interest in the work. Moreover the operations must be directed and supervised by men with practical experience of working soils, familiar with the various conditions both favourable and detrimental to good cultivation and tilth formation and the soil requirements of all crops. As an implement with considerable potential for increased economic production, tractors have come to India to stay. Their effectiveness, however, will depend largely on the skill of those who use them. They are not get-rich-quick machines and those who are contemplating cultivation work on mechanised lines should realize that it will be the extent of their skill together with that of their operators which will decide whether mechanised cultivation will prove an improvement over the present indigenous methods.

Whilst mechanised cultivation permits of greater speed in work and enables larger area to be cropped, it does not alone necessarily ensure bigger crops. By proper adjustment of implements a higher standard of work can be ensured over the whole area cultivated. The same conditions, however, of adequate and timely cultivation, timely sowing and irrigation coupled with adequate manuring and other measures to maintain soil fertility are just as necessary to secure satisfactory yields as with the usual indigenous implements. The high labour and bullock costs now ruling offer an opportunity for the introduction of tractor cultivation, particularly where new land is being brought into cultivation in sparsely populated areas.

Table I gives information relating to the total hours worked by the tractor and acres covered, along with acres per hour and cost per acre, with various types of tractor implements. It will be seen that harrow ploughing was of that used as a substitute for ploughing when ploughs were out of work owing to lack of spares and disc-harrowing replaced grubbing (cultivation) and *vice versa*. Although the tractor was occasionally used for seeding (for example one tractor operating three 6-foot drills) but it was usually at this season so urgently needed for cultivation work that

the seed drills had to be operated by bullocks. Briefly the specification of the tractor given by the makers is as follows :

Rated Draw Bar H.P.	27·99
Rated Belt H.P.	44·04
Forward speeds M.P.H.	$2\frac{1}{2}$, $3\frac{1}{2}$ and 4
Reverse speed	$2\frac{1}{2}$
Engine R.P.M. under load	1,100
No. of Cylinder	4
Bore and stroke	$4\frac{3}{4}$ in. $\times 6\frac{1}{2}$ in.
Pulley R.P.M.	588
Wheel Base	53 in.
Fuel	H.S. Diesel
Shipping weight approx.	7,550 lb.

The costs include (Table II) costs of fuel oil, lubricants, wages of drivers and cleaners (including dearness allowance), cost of spare parts and repair operations (wages, dearness allowance of *mistries* engaged in overhaul and repair), interest on capital and depreciation of both tractor and implements.

The above data refer only to cultivation operations. Harvesting, threshing and handling the produce are not included. These items represent usually about 50 per cent of the cost of production. There are possibilities here for the development of equipment to undertake these tasks at reduced costs. Considerable strides have been made abroad in recent years in the development of suitable harvester thresher equipment. The adjustment of these machines to Indian conditions is a pressing need to complete the chain of mechanised operations required in cereal crop production.

CULTURE BOX : A PRACTICAL DEVICE FOR COLLECTING, PRESERVING, AND TRANSPORTING VIRUS AFFECTED PLANT MATERIALS

By S. P. Capoor, M.Sc., Ph.D. (Lond.), Virus Pathologist, College of Agriculture, Poona

(Received for publication on 25 August, 1951)

(With one text-figure)

SINCE the commencement of research work on plant virus diseases at Poona, a large number of viruses affecting plants have been collected, some locally in or around Poona, and many from district places far away from the central laboratory. Plant materials affected with viruses which could be transmitted by mechanical means, were usually collected in a vasculum and these remained in good enough condition for a sufficiently long period. But there were several other virus diseases, such as the 'small-leaf' disease of cotton [Uppal, *et al.*, 1944], and the 'sterility' disease of pigeon pea [Capoor, 1950], which offered real difficulty when attempts were made to establish them in the glasshouses at Poona, for these could neither be communicated by mechanical means nor were their insect vectors known at the time.

Shoot cuttings of cotton and pigeon pea brought in water were invariably damaged beyond recovery before they reached the laboratory at Poona, and the grafts made with these failed to take union. In order, therefore, to overcome these shortcomings, a suitably devised 'Culture Box' was constructed for preserving and transporting virus affected plant materials to Poona for further investigation. Since the culture box has proved to be of great use here, and that it may be more widely applicable, its construction and some of the results obtained with its help are discussed in the present paper.

The culture box

The culture box consists of a wooden cabinet 11 inches long, 10 inches high and four inches wide. The details of its construction are shown in Fig. 1. The cabinet is made out of half inch thick seasoned teak wood of good quality, and is intended to carry twelve 8 in. × 1 in. rimless Pyrex glass tubes. The tubes are passed through holes in a wooden shelf *a* fixed at the upper end of the cabinet, and are made to rest on shallow depressions in a similar shelf *b* fixed 7 in. below the shelf *a*. The holes in the shelf *a* are made in two rows of six holes each, and the depressions in the shelf *b* correspond to the holes in shelf *a*. The front plank *p* of the cabinet is made to open, and for that reason is fixed by means of two hinges at $1\frac{1}{2}$ in. above the base, and almost in level with the lower shelf *b*. When closed, it is held in position by means of two hooks *h* fixed one on either side of the cabinet at its upper end. The lid, which is $2\frac{1}{2}$ in. deep inside, is held in position with two slip-in hinges, and can be separated from the cabinet at will. When closed, the cabinet forms a neat,

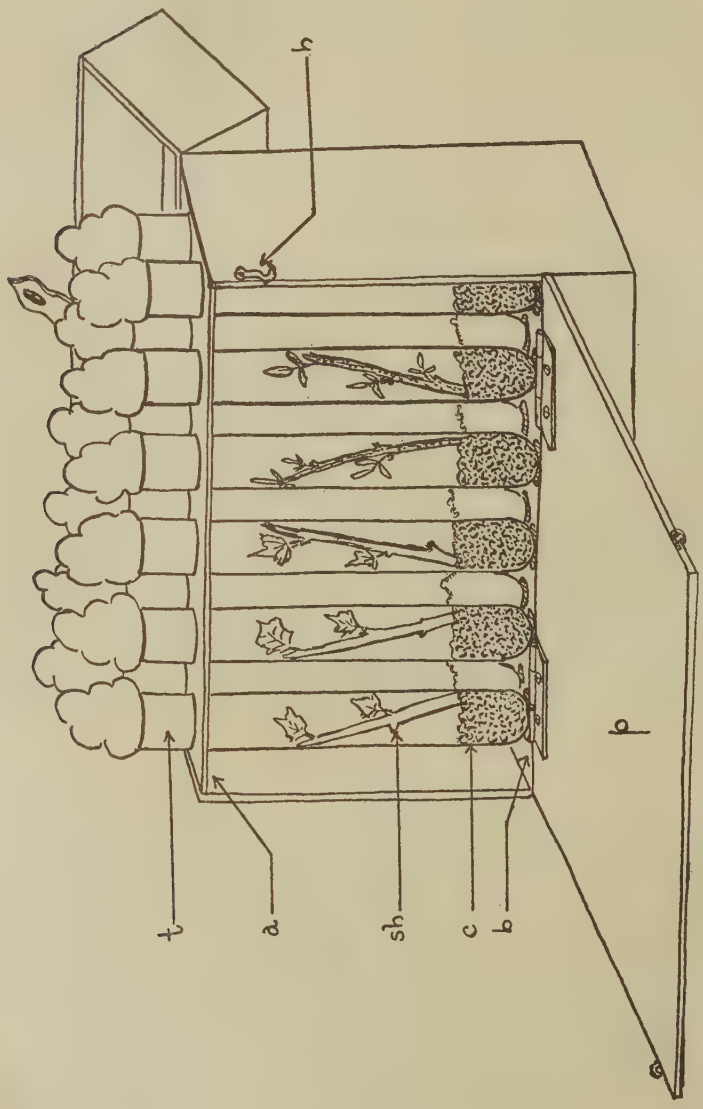

FIG. 1. The culture box with the front plank and the lid open showing the internal construction and the arrangement of tubes, *a*, upper shelf with holes; *b*, lower shelf with depressions; *c*, cotton wool soaked with water or nutrient solution; *h*, hook; *p*, front plank; *sh*, cut shoots; *t*, rimless Pyrex glass tubes 8" × 1".

light, and compact case which is carried conveniently by means of a small handle fixed at the top of its lid. The main purpose of keeping a detachable lid and the front plank opening out is to provide the collected material with full diffused light when the cabinet is not in transit without having to remove the glass tubes from it.

Procedure

Before setting out on a collection trip the tubes for the culture box are prepared as follows :

1. The tubes are washed clean with soap and warm water, and dried.
2. A piece of cotton wool soaked in water is then placed at the bottom of each tube so that the water stands just up to the surface of cotton. Care is taken to remove all air bubbles from the soaked cotton.
3. The tubes are then plugged with cotton wool and sterilized at 15 lb. pressure for 20 minutes. Often during sterilization, water from some of the tubes is lost completely. Such tubes are opened under aseptic condition and the required amount of sterile water is added to them.

Instead of water a full nutrient culture solution* adopted from Ellis and Swaney [1938] was occasionally used for wetting the cotton.

Results

Although the principle of culturing plant tissues affected with virus diseases is the same as followed by Holmes [1930] for the first time, but, as stated earlier, the culturing of virus affected plant materials has been made use of with entirely a different purpose in the present study. Trial tests were first carried out with suitable stem cuttings of some herbaceous and some woody plants stored in the culture box with a view to ascertaining the suitability of the storage tubes for this purpose, and also the duration of time for which some of the plant cuttings could be stored without much inpairing their quality of being used as scion in grafting experiments. In these trials the cuttings were properly surface sterilized in 1 in 1000 $HgCl_2$.

Stem cuttings of *Bhendi* (*Hibiscus esculentus* L.) affected with the yellow vein mosaic virus [Capoor and Varma, 1950] were conveniently stored for a period of 90 days in the culture box, and cuttings of egg plant (*Solanum melongena* L.) affected with the ' little-leaf ' disease [Thomas and Krishnaswami, 1939] and hollyhock (*Althaea rosea* L.) affected with vein-tumours (unpublished) for 30 and 48 days, respectively, before they were used as scion with good success in grafting test plants. Similarly, shoot-cuttings of *Petunia hybrida* Vilm. and *Datura inoxia* Mill. (*D. alba*

* The solution contained the following chemicals per 1000 c.c. of the nutrient :

KH_2PO_4	0·26 gm.
$Ca(NO_3)_2 \cdot 4H_2O$	0·89 gm.
$MgSO_4 \cdot 7H_2O$	0·47 gm.
$(NH_4)_2SO_4$	0·08 gm.
Trace elements	0·5 c.c.
$FeSO_4 \cdot 7H_2O$	A trace.

The stock solution of trace elements was prepared by dissolving together in 562 c.c. of water 0.8 gm. each of boric acid, manganese sulphate and zinc sulphate.

Nees) affected with the ' distortion ' mosaic virus [Capoor and Varma, 1948] were stored for 40 and 30 days, respectively, and used with success in inoculating healthy *Datura inoxia* seedlings.

The culture box has specially been helpful in the collection of new virus diseases and in establishing them in the glasshouses at Poona. Notable success has been obtained in culturing three virus diseases, e.g., ' small-leaf ' disease of cotton, ' sterility ' disease of pigeon pea, and mosaic disease of *Crotalaria retusa*, which do not occur locally and their modes of transmission in nature are also not known as yet. In 17 transmission trials carried out with these diseases 186 plants were grafted on various occasions, and successful transmission of these diseases was obtained in 106 cases. In majority of these experiments, grafts were made within 3 days of collection of the diseased materials, but in those cases where grafting was delayed to 6, 7 or even 8 days the success achieved was most unexpected. The success obtained in these attempts has, therefore, been attributed entirely to the use of the culture box.

ACKNOWLEDGEMENT

I wish to thank Mr. Y. A. Padhye for drawing the figure for me, and the Indian Council of Agricultural Research for financing a Scheme under which this work has been done.

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STUDIES ON THE 'DISTORTION MOSAIC' VIRUS OF *DATURA INOXIA* MILL

By S. P. Capoor, M.Sc., Ph.D. (Lond.), Virus Pathologist and P. M. Varma, M.Sc., Virus Entomologist, College of Agriculture, Poona, Bombay State

(Received for publication on 1 September, 1951)

(With Plates XXII—XXIII)

THE virus affecting *Datura inoxia* Mill was collected for the first time in 1939, and later designated as 'distortion mosaic' of *Datura alba* Nees [Capoor and Varma, 1948]. This pubescent or hairy plant of American origin is the one found to be very abundant in Khandala and other parts of the Bombay State, but always in places near the roads or railway lines. It has been wrongly mentioned in modern Indian floras under the names of *Datura alba* Nees or *Datura metel* L. [Santapau, 1948].

The virus causing distortion mosaic in *Datura inoxia* is very common in the Bombay State and also occurs naturally on *D. metel* L. and *D. metel* L. var. *fastuosa* L. *Datura metel* is of wide occurrence in the southern districts of the Deccan, in North Kanara, and the adjoining states ; and *D. metel* var. *fastuosa* is mainly grown as an ornamental plant in gardens.

Symptomatology, transmission, host range and physical properties of the virus have been studied with a view to establish its identity.

Material and methods

The virus was collected on naturally infected *Datura inoxia* plants at the Agricultural College Estate, Poona, and established on *D. inoxia* in the insect-proof glasshouse where all experiments were conducted. Successive transfers were made to healthy *D. inoxia* seedlings at frequent intervals in order to keep a sufficient supply of fresh inoculum.

Mechanical inoculations were made by the leaf rubbing method with freshly extracted sap taken from young leaves showing characteristic symptoms of the disease. In tests to determine the host range of the virus, use of carborundum powder of 600-mesh fineness as an abrasive was usually made. Shortly after inoculation the inoculum was washed from the leaves with distilled water.

In transmission tests with insects, the insect species used were collected from naturally diseased *Datura metel* var. *fastuosa* and *D. inoxia*. These were either transferred directly to healthy test plants or were first fed on infected *D. metel* var. *fastuosa* in the insectary and transferred to healthy test plants as required. The aphids were first transferred from the diseased plant to a clean paper with a moistened camel's hair brush, and from there to healthy test plants with the help of another sterile brush in order to avoid contamination. With a view to reducing

mortality to the minimum, the aphids were first induced to withdraw their mouth-parts from the food plant by gently touching them on the abdomen with the brush [Severin and Freitag, 1938]. After the aphids had fed on the test plants they were destroyed by spraying the plants with nicotine sulphate. All plants used in these experiments were raised from seed in the insect-proof glasshouse which was regularly fumigated.

Experimental

Symptomatology. The disease, as the name 'distortion mosaic' suggests, produces in *Datura inoxia* a typical dark green mosaic accompanied by severe distortion of leaves. The first symptoms of the disease appear from six to nine days after inoculation in the form of a pronounced vein clearing, curling of margins and upward folding of the youngest leaf near its base followed by discolouration. These symptoms soon become prominent and the entire leaf gradually turns lighter green in colour with a few dark green spots. Subsequent leaves show pronounced curling of margins and almost double folding upwards in the early stages, and later a distinct mosaic pattern and some distortion(Plate XXII, fig. 1).

As the plant grows the developing leaves show puckering in the form of large and raised blister-like darkgreen patches. Often severe malformation and distortion of leaves associated with marked reduction in leaf laminae resulting in tendrils or shoestrings occurs at a later stage of infection, the leaves then consisting of only the midribs (Plate XXII, fig. 2). There is a marked similarity between these symptoms and those caused by the 'Z' disease in *Datura stramonium* [Blakeslee, 1921]. Plants which have been diseased for sometime more often produce leaves which show the characteristic mosaic pattern, although the shoestringing effect is equally common.

Occasionally, some leaves though distorted and reduced in size do not show mosaic mottling at all, but appear homogeneously palish-green and their smaller veins prominently translucent; while others may show only localised discolouration and malformation.

The flowers and flower buds of affected plants are also severely distorted and malformed (Plate XXII, fig. 3B). The floral whorls are imperfectly developed and the flowers do not open in the manner the healthy ones do (Plate XXII, fig. 3A). The corolla usually ruptures the calyx on the side instead of emerging normally at the tip of the calyx whorl, while the stamens and the pistil rupture the corolla in a similar manner (Plate XXII, fig. 3B). In spite of these abnormalities fruits are set, but are smaller in size and contain few but viable seed.

Transmission of the virus

The virus is readily transmitted by sap inoculation and hundred per cent infection is invariably obtained on inoculation to *Datura inoxia* even without the help of carborundum powder.

Seeds from diseased *Datura inoxia* were collected and sown in pots inside insect-proof glasshouse. It was possible to raise 1850 seedlings in May 1941, 600 in December 1943, 720 in June 1946, and 860 seedlings in December 1949. In

Photo : S. P. Capoor

EXPLANATION OF PLATE XXII

FIG. 1. A diseased plant of *D. inoxia* with well defined symptoms of 'distortion' mosaic. Uninoculated plant on the right.

FIG. 2. A diseased plant of *D. inoxia* showing tendril-like leaves.

FIG. 3. (B) Severely distorted flower and flower-bud of *Datura inoxia*. (A) Flower and flower-bud from uninoculated plant.

addition, 300 seedlings raised from seed of healthy plants were also grown as control. All seedlings were normal and healthy from both diseased and healthy parents, showing thereby that the virus was not transmitted through the seed. All plants were kept under observation for 45 days.

Insect transmission. The insect fauna on *Datura inoxia* is both scanty and poor. Few insect species breed on this plant, and others that happen to alight on it or carried there by wind are eventually killed. Very often large number of dead alate aphids are observed sticking to hairs on the stem and leaves. Amongst them the species identified were *Myzus persicae* Sulz., *Aphis gossypii* Glover, *A. laburni* Kalt., and *Macrosiphum pisi* Kalt. Colonies of nymphs of *Aphis gossypii* and *A. neri* Boyer de Fonscolombe are often noticed during the rainy season, but these were never observed to attain maturity. The inability of these insects to colonize freely on *Datura inoxia* is very likely due to the fact that this plant is densely covered on both surfaces with hairs which are generally glandular and emit on the slightest touch a sticky and toxic fluid giving out obnoxious smell, which repels some insects and kills the others.

The only insect that breeds abundantly on *Datura inoxia* all the year round is a bug, *Engytatus tenuis* Rent., and on one occasion a thin colony of the beetle, *Lema nigrovittata* Guer. was observed on its leaves. On *Datura metel* var. *fastuosa* large colonies of aphids (*Myzus persicae*, and *Aphis gossypii*), a fulgorid, coccid (*Phenococcus* sp.), and white-fly (*Bemisia tabaci* gen.) commonly occur. Of the above insects, the aphids and the fulgorid breed from August to March, the coccid during winter and the white-fly all the year round. Except the fulgorid and the coccid, the other insects were used in transmission tests.

Adults of the bug, *Engytatus tenuis*, and the beetle, *Lema nigrovittata*, were collected from diseased *Datura inoxia* plants, while other insects were collected from diseased *D. metel* var. *fastuosa* and liberated on healthy *D. inoxia* seedlings directly in some cases, but were usually fed or colonized on *D. metel* var. *fastuosa* in the insectary before liberating them on test plants. The results of these tests given in Table I, show that only *Myzus persicae* and *Aphis gossypii* are the vectors of the virus.

Transmission of the virus from *D. metel* var. *fastuosa* to plants of the same species as well as to *D. inoxia* by the two aphids was readily obtained. In a series of experiments, the virus was transmitted by *Myzus persicae* from *D. metel* var. *fastuosa* to six out of six plants of the same species and 15 out of 30 *D. inoxia* plants. Whereas, *M. persicae* transmitted the virus from *D. inoxia* to *D. inoxia* only in three out of 29 plants colonized by these insects. This may be due to the fact that both species of aphids died on *D. inoxia* within 12 hours of their liberation on these plants.

Host range of the virus

The host range of the virus is confined to the family Solanaceae and, except *Tetragonia expansa* Murr. in which the virus produced only local necrotic rings, all attempts to infect 26 species in seven families have been unsuccessful.

TABLE I

Insect transmission of Datura 'distortion' mosaic virus

Insect species	Number of insects per plant	*Datura inoxia*	
		Inoculated	Infected
Engytatus tenuis	10 to 16	21	0
Lema nigrovittata	4 to 6	4	0
Myzus persicae (alate)	10 to 20	14	5
M. persicae (aptarous)	20 to 30	20	8
Aphis gossypii (alate)	15 to 20	19	16
A. gossypii (aptarous)	20 to 30	13	4
Remisia tabaci	15 to 25	15	0

The virus produced milder symptoms in *Datura metel* and *D. metel* var. *fastuosa* as compared to those in *D. inoxia*. Leaves of naturally infected plants as well as of those artificially diseased developed a fine-grain mosaic mottling, and occasionally faintly chlorotic patches (Plate XXIII, fig. 3). Malformation of leaves or flowers did not occur in these plants. *Datura chlorantha* Hook. developed symptoms of the disease very much similar to those on *D. inoxia*.

In addition, the virus has been **experimentally transmitted** by sap inoculation to *Datura stramonium* L ; *Petunia hybrida* Vilm ; *Lycopersicon esculentum* Mill.; *Nicotiana tabacum* vars. White Burley, Adcock, Gold Dollar, Mammoth Gold, and Turkish ; *N. sylvestris* Spegaz. and Comes. ; *N. rustica* L. ; *N. glutinosa* L. ; *N. glauca* Grah. ; (*N. tabacum* × *N. glutinosa*) hybrid ; and *Capsicum frutescens* L.

Datura stramonium. Necrotic spots appeared in 3-4 days on the inoculated leaves and rapidly grew in size and coalesced to form large necrotic patches (Plate XXIII, fig. 4). This was followed in about six days by a reddish brown necrosis of the major veins, owing to which the inoculated leaves were curled downward and inward, and ultimately destroyed. The necrosis, in some cases, was extended into the petiole and thence to the stem below the leaf attachment developing into a large stem lesion, but it did not become systemic, the young growth showing no symptoms of disease and remaining entirely free of the virus.

Petunia hybrida. The virus produced symptoms similar to those on *Datura inoxia*, accompanied by marked reduction in size of leaves and dwarfing. The diseased plants often turned completely pale in colour.

Lycopersicon esculentum var. Bonny Best. Tomato plants developed a faint mosaic mottling of the youngest leaf in about 10 days after inoculation. As the leaf

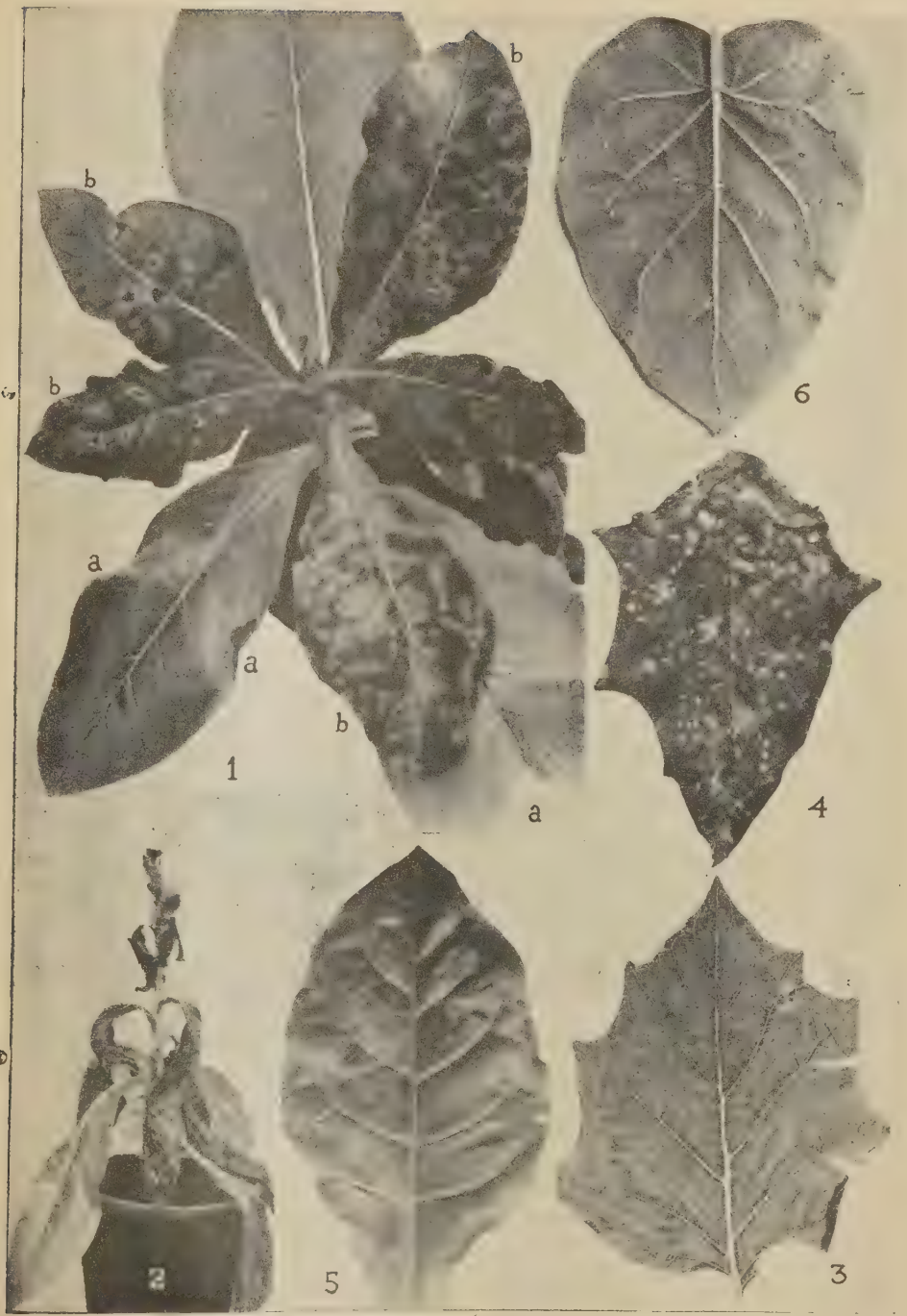

Photo: S. P. Capoor

EXPLANATION OF PLATE XXIII

FIG. 1. A plant of *Nicotiana tabacum* var. White Burley infected with the virus, showing *a*, enlarged local lesions; and *b*, secondary infection of brownish-red solid necrotic spots with yellowish haloes. (Photo after 34 days of inoculation.)

FIG. 2. A White Burley tobacco plant killed due to systemic necrosis. (Photo after 65 days of inoculation.)

FIG. 3. A leaf of *D. metel* var. *fastuosa* showing fine-grain mosaic mottling and a chlorotic patch.

FIG. 4. A leaf of *D. stramonium* infected with the virus, showing local necrotic lesions.

FIG. 5. A leaf of infected Turkish tobacco plant with secondary necrotic rings.

FIG. 6. A leaf of *Nicotiana glutinosa* with local necrotic lesions.

enlarged the mosaic symptoms gradually became indistinct. Subsequently developing leaf showed a conspicuous puckering of dark green blisters, but this leaf also outgrew the disease symptoms on maturity. Later the plant remained a symptomless carrier of the virus. Tomato variety Ox Heart was highly susceptible and could be readily infected with the virus even without the help of an abrasive.

Nicotiana tabacum var. White Burley. In tobacco local lesions appeared on the inoculated leaves in four to six days. The lesions when formed were solid chlorotic spots of about 2-3 mm. in diameter. These later became necrotic in the centre and gradually enlarged to 12-15 mm. (Plate XXIII, fig. 1a). Systemic infection appeared in about 15 days in the form of necrotic spots all over the leaf surface (Plate XXIII, fig. 1). The secondary lesions were small with a brownish-red solid necrotic spot in the centre, and each surrounded by a yellowish halo (Plate XXIII, fig. 1b). The affected leaves gradually lost their normal green colour, turned almost yellowish brown, and ultimately collapsed. Large necrotic lesions also appeared on the stem, and the necrosis affected the growing shoot and proved fatal (Plate XXIII, fig. 2). At temperature ranging between 98 and 108°F. which is quite common during summer months in the glasshouses, the infected tobacco plants collapsed almost suddenly due to systemic necrosis. In some plants the systemic necrosis was preceded by partial green veinbanding of younger leaves.

Occasionally, an infected White Burley tobacco plant produced leaves which (*a*) were free of any symptoms of disease, (*b*) had a solitary necrotic spot or several necrotic lesions formed only on one half side, and (*c*) had numerous necrotic spots all over the lamina. The external symptoms on leaves of such plants are correlated with the distribution of the virus, for no infection was obtained when extracts from a symptomless leaf or healthy looking portion of a leaf were used as inoculum.

Nicotiana tabacum var. Turkish. Local lesions did not develop on the inoculated leaves of Turkish tobacco, but systemic infection appeared as mild mosaic mottle of broad patches in the younger leaves, while the older ones developed concentric broken rings here and there (Plate XXIII, fig. 5). A severe necrosis of the type on White Burley tobacco does not appear on this plant.

Nicotiana sylvestris. The initial symptoms produced were similar to those in White Burley tobacco. Systemic infection appeared in the form of a well defined green vein-banding mosaic in about 15 days, but necrosis did not appear in any form.

Nicotiana rustica. A large number of small solid necrotic spots appeared within six days on the inoculated leaves followed about a week later by systemic necrosis. Often the necrosis proved lethal to the infected plants.

The inoculated leaves of *Nicotiana tabacum* × *N. glutinosa* hybrid developed necrotic lesions about 1 mm. in diameter. These leaves died within 10 days, and later the plants also collasped suddenly without developing systemic necrosis. The virus was not recovered from the uninoculated leaves of these plants.

Only necrotic local lesions appeared on the inoculated leaves of *Nicotiana glutinosa* (Plate XXIII, fig. 6), *N. glauca*, *N. tabacum* vars. Gold Dollar and Mammoth Gold ; concentric rings on those of *N. tabacum* var. Adcock ; and faintly chlorotic spots on the inoculated leaves of pepper (*Capsicum frutescens*). Local lesions

appeared in 3 to 10 days depending on weather conditions, but the disease did not become systemic in any of these plants, and from none of them the virus was recovered when subinoculated from newly formed leaves to *Datura inoxia.*

Infection with the virus was not obtained on any of the following plant species, and from none of them the virus could be recovered on subinoculation to *Datura inoxia* :—CHENOPODIACEAE-*Beta vulgaris* L., *Spinacia oleracea* L. ; LEGUMINOSAE-*Cassia sophera* L., *Crotalaria juncea* L., *Dolichos lablab* L., *Glycine Max* Merr., *Phaseolus vulgaris* L., *P. lunatus* var. *macrocarpus* Benth., *P. limensis* Macf., *Vigna sinensis* Savi, *Vicia faba* L. ; MALVACEAE—*Hibiscus esculentus* L. ; VIOLACEAE-*Viola odorata* L. ; SOLANACEAE—*Nicotiana atroperpureum* Hort., *Physalis Alkekengi* L., *P. peruviana* L., *Solanum melongena* L., *S. nigrum* L., *S. nodiflorum* Jacq.; CUCURBITACEAE—*Luffa acutangula* Roxb., *Lagenaria vulgaris* Ser., *Cucumis sativus* L. ; COMPOSITAE—*Dahlia pinnata* Cav., *Helianthus annuus* L., *Tagetes erecta* L., *Zinnia elegans* Jacq.

Physical properties of the virus

(i) *Thermal inactivation.* The thermal inactivation point of the virus was determined in freshly extracted juice from young leaves of infected *Datura inoxia.* Ten ml. of undiluted diseased sap was contained in thin-walled test tube and heated for 10 minutes in a water bath maintained at the desired temperature. After treatment the sap was cooled rapidly in ice-cold water and then inoculated to *Datura* seedlings. Table II shows that while hundred per cent infection was obtained with juice heated at 58°C., only 11·7 per cent infection occurred with that held at 60°C., and the virus was completely inactivated by heating at 62°C. The results indicate a high temperature coefficient of inactivation for the virus, correlated probably with protein denaturation.

TABLE II

Thermal inactivation point of Datura 'distortion' mosaic virus

Temperature °C	*Datura inoxia* plants	
	Inoculated	Infected
Unheated	12	12
40	12	12
50	12	12
53	10	10
56	15	15
58	15	15
60	17	2
62	5	0
65	5	0

(ii) *Longevity* in vitro

Tests were made to determine the longevity of the virus in diseased *Datura inoxia* juice stored in stoppered bottles in the dark at (1) room temperature (92-94°F.),

(2) at 80°F., and (3) at 45°F. Daily inoculations of the sap stored *in vitro* were made on *D. inoxia* seedlings for a period of 16 days, and at suitable intervals thereafter with the sap held at 45°F. The results of such tests are given in Table III.

TABLE III

Tolerance of the virus to aging in vitro

Days exposed	Room temperature		80°F.		45°F.	
	Plants inoculated	Plants infected	Plants inoculated	Plants infected	Plants inoculated	Plants infected
0 (Control)	5	5	..	..	..	..
1	5	5	5	5	5	5
2	5	5	5	5	5	5
3	5	5	5	5	5	5
4	5	5	5	5	5	5
5	5	5	5	5	5	5
6	5	0	5	2	5	5
7	5	0	5	0	5	5
8	5	0	5	2	5	5
9	5	0	5	1	5	5
10	5	0	5	1	5	5
11	5	0	5	1	5	5
12	5	0	5	0	5	5
13	5	0	5	1	5	5
14	5	0	5	0	5	5
15	5	0	5	0	5	5
16	5	0	5	0	5	5
36	..	..	..	..	15	12
66	..	..	..	..	10	10
81	..	..	..	..	10	5
100	..	..	..	..	10	6
132	..	..	..	..	10	0

Evidently the virus lost infectivity within six days at room temperature while remained infective for almost 13 days at 80°F. and over 100 days at 45°F.

(iii) *Dilution end-point*

The expressed juice from diseased *Datura* plants was diluted with sterile distilled water, and tested for tolerance to dilution both on *D. inoxia* seedlings and on *Nicotiana glutinosa*. The results given in Table IV show that when tested on *D. inoxia* the virus produced only 8 per cent infections at a dilution of 1 in 10,000, and none at all at 1 in 100,000 ; but infection at the rate of about a lesion per leaf of *N. glutinosa* was obtained at 1 in 100,000 dilution.

TABLE IV

Dilution end-point of the virus

Dilution	*Datura inoxia* plants		Local lesions per leaf of *N. glutinosa* (average of 6 leaves)*
	Inoculated	Infected	
Undiluted	30	30	..
1 : 10	40	40	136·8
1 : 100	50	47	268·2
1 : 1,000	50	23	159·2
1 : 10,000	50	4	47·9
1 : 100,000	30	0	5·7
1 : 1,000,000	11	0	0·0

*The average was obtained by the 6x6 Latin Squares arrangement.

(iv) *Resistance to alcohol*

Equal quantities of undiluted juice from leaves of diseased *Datura inoxia* and percentages of ethyl alcohol were mixed, thoroughly agitated and stored separately at 45°F. After suitable intervals, beginning from 2 hours to 30 hours, the mixture was spun in a centrifuge for 10 minutes at 3000 r.p.m. and the alcoholic supernatant fluid was discarded. The precipitate, which contained most of the virus, was resuspended in distilled water and tested by inoculation on *D. inoxia* seedlings. The results indicate that the virus withstood treatment with 95 per cent ethyl alcohol even for 30 hours without showing any appreciable loss in infectivity.

(v) *Resistance to desiccation*

The effect of desiccation on the virus was determined by drying young leaves of diseased *Datura inoxia* and also undiluted expressed juice. When completely

dry the leaves were soaked for some time in distilled water, ground to a fine pulp in a mortar, and the extracted juice used as inoculum. Similarly, the dried expressed juice was first soaked in distilled water and then used as inoculum. The results in Table V show that the virus in leaves dried in the sun was almost completely inactivated within 5 hours, while it remained infectious in leaves dried for 3 days at laboratory temperature. When desiccation was rapid and completed within 5 days at the laboratory temperature, the virus retained infectivity, but when it was slow and took more than 5 days, the virus was completely inactivated unless dried at 45°F. It appears, therefore, that slow dehydration at laboratory temperature favours reactions of plant constituents, specially enzymes, that are injurious to the virus, and that these reactions are eliminated when dehydration is carried out at low temperature.

TABLE V

Effect of desiccation on the virus

Treatment	Period of dehydration	Per cent loss in weight	*Datura inoxia* plants	
			Inoculated	Infected
A. Leaves				
(*a*) Dried over dessigel "S" in a desiccator at room temperature	(i) 8 days	..	10	0
	(ii) 2½ „	72·12	10	7
	(iii) 3 „	83·50	10	10
(*b*) Dried in an open pan at room temperature	(i) 3 „	81·50	10	10
	(ii) 3 „	83·59	5	5
(*c*) Dried in the sun	5 hours	81·0	10	1
B. Expressed juice				
(*a*) Dried over dessigel "S" in a desiccator at room temperature	(i) 10 days	79·21	10	0
	(ii) 6 „	83·72	10	0
(*b*) Dried in an open pan at room temperature	11 „	80·81	10	0
(*c*) Dried over dessigel "S" in a desiccator at 45°F.	18 „	83·09	10	9

DISCUSSION

A large number of plant viruses are known to affect *Datura stramonium*, for some of which it has been used as a 'filter' plant [Smith, 1931 ; Valleau and Johnson, 1931], and for others as a differential host [Bald, 1943 ; Matthews, 1949] ; but no virus disease has yet been recorded on *Datura inoxia*. Also eight different viruses have been reported to occur naturally on *Datura* spp. but none of these bears any resemblence to the *Datura* 'distortion' mosaic virus, the subject of this paper.

Of those viruses occurring naturally on *Datura*, the 'Quercinia' and 'Z' mosaic were recorded by Blakeslee [1921] who showed that both were infectious in nature. 'Quercinia' was transmitted by grafting, by seed, and also by pollen; but not by sap inoculation. 'Z' mosaic could be communicated by sap but not through seed. No information is available on the properties and host ranges of these viruses, but the symptoms produced by 'Z' mosaic on *Datura stramonium* are distinct from those produced on it by the 'distortion' mosaic virus. Another virus occurring naturally on *D. stramonium* is Cucumber virus 1 [Ainsworth, 1934], which has physical properties similar to those of the 'distortion' mosaic virus, but differs from the latter in having a distinct host range and causing systemic yellow chlorotic mottling in *D. stramonium*. Yu [1930] only made a mention of the existence of mosaic of *D. metel* in China. Of the remaining four diseases the "little-leaf" of egg plant [Thomas and Krishnaswami, 1939], and the 'big-bud' disease [Hill, 1940], are not aphid-borne or transmitted by mechanical means, but are transmitted in nature by jassids. The 'Kromnek' disease which also affects *Datura* spp. in nature, has been discovered to be caused by the tomato spotted wilt virus and transmitted in nature by the thrips, *Frankliniella schultzei* Trybom. [Moore and Anderssen, 1939].

The only disease that calls for comparison with the 'distortion' mosaic virus is *Datura* virus 1 [Smith, 1937]. Although the physical properties of the two viruses are quite distinct, they also differ widely in their host ranges and symptom expression. *Datura* virus 1 induces in *D. stramonium* a systemic yellow flecking and mild necrosis in addition to necrotic local lesions, while the 'distortion' mosaic virus causes only local necrosis. The disease produced in *Nicotiana tabacum* var. White Burley and in tomato by *Datura* virus 1 is also quite distinct from that produced in these plants by the 'distortion' mosaic virus. While *Datura* virus 1 is infectious to *Phaseolus vulgaris* and *Vigna sinensis*, 'distortion' mosaic virus does not infect these plants and also others in the family Leguminosae.

It is obvious, therefore, that the 'distortion' mosaic of *Datura inoxia* is caused by a distinct virus which has not been previously described. The physical properties and transmission of the virus indicate that it is of low concentration and stability, and, therefore, falls in the group of aphid-borne non-persistant viruses which includes also the potato virus 'Y', Hyoscyamus virus III, tobacco etch viruses, tobacco ring spot virus, and Cucumber virus 1.

Nomenclature and classification

The characteristic mosaic pattern produced on *Datura inoxia* by the 'distortion' mosaic virus, and the fact that the causal agent is transmitted by juice inoculation characterise the virus to be included in the genus *Marmor* of Holmes [1948]. Following Holmes' binomial system of virus nomenclature and classification, the name *Marmor daturae* is proposed for the virus:

MARMOR DATURAE n. sp.

Common name Datura 'distortion' mosaic virus.

The virus causes a conspicuous mosaic mottling accompanied with puckering and severe distortion of leaves and flowers. The host range of the virus is confined to the family Solanaceae with the exception of *Tetragonia expansa* Murr.,

in which the virus produces only necrotic rings on the inoculated leaves. The virus is juice-transmissible by the rubbing method of inoculation, and its vectors are *Myzus persicae* Sulz. and *Aphis gossypii* Glover.

Descriptive habitat Bombay State, India.

According to Smith's [1937] system of classification and nomenclature the virus should be named as *Datura* virus 3, because the 'little-leaf' disease of egg plant has been designated as *Datura* virus 2 by Thomas and Krishnaswami [1939].

Summary

A new virus disease characterised by severe puckering and distortion of leaves and flowers of *Datura inoxia*, designated as *Datura* 'distortion' mosaic virus, has been described. The virus is readily transmitted by sap inoculation, and by the aphids *Myzus persicae* and *Aphis gossypii* in nature. It is not carried through seed of diseased plants. The host range of the virus is limited to the family Solanaceae, except for *Tetragonia expansa* in which concentric local rings are produced.

The causal virus is inactivated by heating for 10 minutes at 62°C., and after exposure to the air at room temperature for 6 days. On storage at 80°F., it gave infections upto 13 days, while at 45°F. it remained infective for more than 100 days. It is also inactivated at a dilution of 1 in 100,000. The virus, however, withstands exposure to 95 per cent ethyl alcohol for 30 hours, and complete desiccation at 45°F., but not at room temperature, specially when the desiccation is slow and exceeds 5 days.

The virus is given the binomial *Marmor daturae* n. sp. according to Holmes, and the numerical *Datura* virus 3 in the system of classification by Smith.

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REVIEWS

AGRICULTURAL CO-OPERATION IN THE COMMONWEALTH

By Marget Digby

(*Published by Basil Black well, 49 Broad Street—Oxford, 1951, pp. 172, Price 15 s. net*)

THIS book traces the development of co-operative movement for over a hundred years in the Commonwealth countries covering some 40 different territories of the world. It contains limited economic analysis of the development of the movement for the simple reason that the author herself has clearly emphasised that her objective all along has been to narrate the experience gained in the several countries. But the experience narrative is the most useful and the strongest part of the publication and should be of great assistance to all those interested in promoting co-operative effort in the various economic aspects of the urban and rural society. The book clearly brings out that the easiest work in co-operation is the organisation of co-operative credit for the simple reason that it is most easy to organise and administer with the assistance of law. Leaders of co-operation in India often feel proud about the development of co-operation in the country on the ground that India stands first in the world either in the number of societies or the number of members or the total volume of business. They, however, forget that these points of pride entirely relate to co-operative credit.

Though it has been now recognized that greater attention should be paid to non-credit and multi-purpose co-operation, the scope and limitation of such work in countries like India do not seem to be properly appreciated and provided for. Time and again, great emphasis is placed on the development of marketing co-operatives and one leading co-operator in India has even gone to the extent of declaring that the future of co-operation in this country depends almost entirely on the development of marketing co-operatives. The book contains an excellent extract of observations on co-operative marketing made by the Registrar, Co-operative Societies in Ceylon where conditions are, more or less, similar to those existing in India. It should greatly assist if this extract is re-produced :

> 'Marketing is an operation which always sounds delightfully easy. You have only to arrange for all your producers to collect their produce at a certain place and a certain time and then, by virtue of the improved bargaining power which you get from handling a large quantity and reduced costs of transport, proceed to sell it on improved terms.

Actually, however, it is extremely difficult, as a very little experience soon shows. First the collection breaks down. Some of your producers are cut off by an impassable stream; many others have gone to a wedding and will bring their stuff tomorrow, when your lorry or whatever it is has gone; many more have been beguiled by the sight of a little hard cash and the promise of more, into selling to the local trader; others are tied to the local boutique keeper, to whom they owe money—if they do not take their produce to him at his price, he will put them in court and sell their lands. But they never told you a word about this when they promised to bring their produce. Usually there is such a complete breakdown at this stage, that the whole scheme collapses. But if you surmount the obstacle, there are plenty more. Your individual member must have cash, and cannot wait for it. You can only afford to pay him a conservative fraction of the anticipated final price, but to do even this you need a very large sum of money, which you have not got and cannot borrow, because no one will lend on the security of a lot of produce which has not yet been collected, to a society which will very likely collapse. You can hardly even guarantee that you will collect produce with sufficient certainty to justify Government in putting up a warehouse in which to collect it. If you get that far, you have next to arrange to get it sold without illicit commissions, work out accounts of all transport and other expenses, and pay the balance due to the producers scattered all over the country. Throughout the whole transaction you will be dogged by the mistrust of the original producer, who has parted with his produce on a partial payment, and strongly suspects that distant people whom he does not know have cheated him or will shortly do so. Needless to say their suspicion and mistrust is actively fostered by the agency which formerly bought these goods, and has no desire to be ousted by your organisation. On a co-operative basis all this has to be done by an association formed by the producers themselves, i.e. cultivators pitted against traders, trying to beat them at their own game and oust them from a market which they already hold.'

The book clearly brings out that the real success in co-operation could be obtained only in those countries where the human material for which it was intended was ready to adequately absorb and appreciate the economic and social value of the movement. As Prof. C. R. Fay observes in his able foreword, if co operation is to succeed, (i) it must receive expert handling with highest possible business efficiency, (ii) the co-operators must be always willing to co-operate with other parties and (iii) all co-operators must understand and scrupulously follow all the principles of co-operation. The great importance of these three elementary rquirements of co-operation is brought out almost at all stages of the book which is recommended to all those interested in the development of the movement in India. (T. G. S.)

THE PLACE OF CO-OPERATION IN THE FIRST FIVE-YEAR PLAN OF THE PLANNING COMMISSION

By R. G. Saraiya

(*Published by the Bombay Provincial Co-operative Institute, Bombay—pp. 19, Price as. 8.*)

AN attempt has been made in this pamphlet 'to bring together all the recommendations of the Planning Commission bearing on the Co-operative Movement and to discuss them'. The author, who is one of the leading Co-operators in the country, has welcomed several suggestions of the Planning Commission for utilization of co-operatives in the development of agriculture, fisheries, cottage industries, housing, etc. He has not expressed any opinion on the proposed long-term objective of Co-operative Village Management, but his silence, in the context of his critical comments, may be taken to imply his concurrence to the proposal. The promotion of cottage industries is recognised as second in importance only to agriculture. He, therefore, desires that in assigning the work of development of these industries, organisations of semi-public character, which are likely to be more responsive to the public opinion, should be preferred to departmental organisations; and further repeats the recommendation, made by the Co-operative Planning Committee and later on also by the Informal Conference of the Reserve Bank, that to enable the Co-operative Banks to finance industrial societies properly, the Reserve Bank should be allowed to give accommodation to them for the purpose.

Notwithstanding his satisfaction with many proposals of the Commission, the author, on the whole, seems to be dissatisfied due to what he considers to be the Commission's failure to lay sufficient emphasis 'on the vital role which the Co-operative Movement can play both in implementing plans of the States in a democratic manner and also in offering suggestions based on local knowledge for the amendment, adaptation, or modification in the light of actual field experience'. He would like Committees of Co-operatives to be associated with every stage of the developmental machinery in a Development Block. He desires that in the organisation of Village Production Councils, a definite preference should be shown to the Co-operative Societies as against the village *panchayats*, in areas where the Movement has fairly well developed. The matter, however, is one which needs to be examined in the context of the wide scope and functions envisaged for the Village Production Council, which will not only serve 'all classes of farmers' within the village, but will also organise voluntary labour for community works and, 'assist in the provision of requirements of raw-material for the artisans of the village'. His other suggestions, *inter alia*, relate to the organisations of Labour Contract Societies for such purposes as developmental work, building of canals, wells, banks, roads, schools, running of transport organisations, etc. and utilization of the services of the Co-operative Societies in the key village scheme of cattle improvement.

The author has a wide experience of Co-operative problems in this country and his suggestions no doubt merit serious consideration. It has, however, to be kept in view that his approach is rather limited, which leaves out administrative and financial aspects. (S. R. S.)

FOUR THOUSAND MILLION MOUTHS

EDITED BY F. LE GROS CLARK AND N.W. PIRIE

(*Published by Oxford University Press, 1951, pp. 222, 12s. 6d.*)

THE population of the World, at present estimated to be about 2,300 millions, is increasing at the rate of about 1 per cent per year ; at this rate there will be 4,000 million mouths to feed before a century passes. There seems to be two schools of thought among those who have given serious consideration to this alarming prospect. One school holds that unless the increase in population can be stopped by some means or other, there is nothing that stands between humanity and starvation in the near future. The other school believes that science and technology if properly harnessed, can lead to such an increase of food production that the threat of starvation will not materialize. The editors of *Four Thousand Million Mouths* subscribe to the second viewpoint. They do not underestimate the need for educating people to limit the population by placing a voluntary check over their own fecundity but are dubious about the quick success of such attempts so far as the masses of illiterate and unenlightened peasants are concerned. Believing that even with the present rate of population increase, starvation is not imminent for about a hundred years, provided wastage is prevented and the maximum utilization is made of natural resources through the application of our present knowledge of science, they asked a group of British Scientists, each an authority in his field, to describe the way in which knowledge and skill could be used for the production of more food. The result is the present book consisting of eleven essays meant mainly for non-scientific laymen.

The first essay entitled 'the Malthusian Heritage' describes the broad historical setting of modern views on population. 'Conserving the Soil' treats the important topic of soil erosion. The problem of fertilizers is considered in the next chapter by Dr Yates of Rothamsted Experimental Station. Citing statistics obtained in England he discusses the roles of organic and inorganic fertilizers and the place of animals in agriculture. In his essay on 'Growing Healthier Crops' Mr. Bawden points out that the reduction in the incidence of diseases in plants will lead to greatly increased yields ; perhaps the increase will amount to as much as hundred per cent of present production. He rightly stresses the urgent need for vastly increasing the number of plant pathologists—in particular in the backward countries. Constant vigilance and extensive research are needed to combat the new types of pathogens that arise from time to time and infect crops. Dr Harland of Manchester University dicusses the increase in food production that can be brought about by proper plant breeding. The two following essays take up specific food items milk and pig meat.

'Harvesting the Waters' and 'The Preservation of Fish' form a sequence of informative essays describing another source of food that can be tapped with much greater efficiency than at present. Food technology, though of recent origin, has a great deal of help to offer in this connection. Even the present catch of fish can yield substantially increased amounts of food products if proper use is made of refrigeration, dehydration, canning and the newly developed technique of freeze drying. Waste recovery is a powerful supplement of other methods of increasing our food supply. Mr. Pirie, also of the Rothamsted Experimental Station, discusses some of its important aspects. The book ends with an essay 'on the Processing of Food' that describes man's ingenuity in preparing and conserving food and also points out the difficulties that the food scientist and food technologist run into securing 'customer acceptance' for new food or old food prepared by a new process.

The different chapters of the book do not form an all-inclusive study of the problem of increased food production. Further, the experts have mostly drawn on their experiences in the United Kingdom in writing their articles, although the need for greater food supply is most acutely felt in the less developed parts of the World. It would have enhanced the value of the book to have included chapters on the special steps that can be taken for producing more food in Asia and Africa.

All the essays in the book are very readable and informative. After reading them one feels that all is not lost, that there is yet hope for humanity at the brink of starvation. It is a book that should be welcome in these days of gloom when the Malthusian spectre is haunting all thinking minds. (J. C. G.)

COFFEE, TEA AND COCOA—AN ECONOMIC ANALYSIS

By V. D. Wickizer

(Published by Food Research Institute, Stanford University, Stanford, California, 1951, pp. 489, price $ 5·00)

THE Food Research Institute of Stanford University deserves to be congratulated for having brought out a useful book relating to coffee, tea and cocoa. The book gives a comprehensive account of the origin, growth and development of coffee, tea and cocoa economy and also attempts international analysis of the problems confronting trade in these commodities. It would be found particularly useful by students interested in international trade. The book is divided into 19 Chapters and contains in addition 12 appendices containing a good deal of useful data. (S.R.S.)

HYDROPONICS—THE BENGAL SYSTEM

By J. Sholto Douglas

(Published by Oxford University Press 1951, pp. XII—147. Rs. 6)

THE book gives a non-technical account of the development of the technique of hydroponics along with complete practical details of the so-called Bengal system. Amateurs interested in the hobby of hydroponics will find in this book a good practical guide.

The author does not claim that hydroponics can entirely replace agriculture. According to him, 'what has been proved beyond doubt is that waste land, rocks, even house-tops and back verandahs—anywhere that sufficient sunshine and water are made available—can be made to bloom and bear as well, and often better, at much less cost and trouble'. The reviewer hopes that a few enthusiastic amateurs would seriously take notice of the author's statement and give the benefit of their experience to professional agriculturists after thoroughgoing trials. Only then perhaps will the controversy regarding the wide-scale applicability of hydroponics be satisfactorily settled. (R.D.A.)

AGRICULTURAL LABOUR ENQUIRY REPORTS

By the Ministry of Labour, Government of India

(*Published by the Manager of Publications, Civil Lines, Delhi*)

1. Report on an enquiry into the conditions of agricultural workers in village Vandalu in Madras State. Price Re. 1, as. 10 or 2*s*. 6*d*., pp. 73
2. Report on an enquiry into the conditions of agricultural workers in village Dorwan in Bihar State. Price Re. 1, 6 as. or 2*s*., pp. 81
3. Report on an enquiry into the conditions of agricultural workers in village Archikarahalli in Mysore State. Price Re. 1, 10 as. or 2*s*. 6*d*. pp., 79
4. Report on an enquiry into the conditions of agricultural workers in village Khapri in Madhya Pradesh State. Price Re. 1, 6 as. or 2*s* , pp. 87
5. Report on an enquiry into the conditions of agricultural workers in village Brindabanpur in West Bengal. Price Re. 1, 6 as. or 2*s*., pp. 73
6. Report on an enquiry into the conditions of agricultural workers in village Magurapara in Assam State. Price Re. 1, 12 as. or 2*s*. 6*d*., pp. 76
7. Report on an enquiry into the conditions of agricultural workers in village Khuntuni in Orissa. Price Re. 1, 12 as. or 2*s*. 6*d*., pp. 94
8. Report on an enquiry into the conditions of agricultural workers in village Khalispur in U. P. State. Price Re. 1, 8 as. or 2*s*. 3*d*., pp. 97

Prior to the commencement of the Agriculture Labour Enquiry, which is the first All-India enquiry into the conditions of agricultural workers, the Ministry of Labour organised, as was recommended by the United Nations Sub-Committee on Sampling, a pilot enquiry in 27 selected villages in eight States during June to November, 1949, with a view to testing the suitability of the proposed questionnaires and instructions and obtaining an idea of the organisation necessary for the main enquiry. The aforesaid eight reports give the information collected during the pilot enquiry in respect of one village in each of the eight States. The reports follow a uniform pattern ; each gives a brief account of the enquiry itself, full texts of the questionnaires and instructions which were issued, background information for the village and a variety of statistical data relating to employment opportunities, wages,

standard of living and indebtedness of agricultural workers in the village concerned. The improvements recently suggested by the I. L. O. in their *Methods of Family Living Studies, 1949* have also been carried out to the fullest extent possible in the analysis of the data and their presentation. However, as is pointed out in the preface to each of these reports, the data, being for a preceding year, can only be regarded as a first approximation in view of the illiteracy and short memory of the villagers. No conclusions can obviously be drawn for the country or the State concerned on the basis of these type studies. More light will be thrown on the conditions of agricultural labourers, when the reports of the main enquiry, which are at present under preparation in the Ministry of Labour, are published. In the meanwhile, these type studies might be found interesting as an indication of the type of information that would become available in the reports of the main enquiry. (S.R.S.).

GUR INDUSTRY IN INDIA

By S. C. Roy.

(*Published by Indian Central Sugarcane Committee, 1951, pp. 300, Price Rs. 12-12-0 or £1.*)

BY far the greater amount of sugar consumed in India is in the form of *gur* or jaggery (raw brown sugar made by the evaporation of cane or palm juice in open pans to a point where the resultant massecuite sets to solid lumps on cooling or to a highly crystalline semi-liquid form) whose annual production in the country is almost three times that of white sugar. The fact that the protection granted in 1932 to the white sugar industry has had little or no effect on this widespread cottage industry clearly shows that *gur* is an integral part of the dietary in Indian homes and will no doubt continue to be so for a long time to come. Although an age old industry of considerable importance in the rural economy of the country, the manufacture of *gur* is carried out on very wasteful lines and the small cultivator, in whose hands the industry almost entirely rests, makes use of highly inefficient and crude processes, which occasion a recurring national loss of immense magnitude. The need for amelioration of this industry has been acutely felt for some years past and a few workers and institutions have appreciated the need for tackling its problems in a really scientific manner. For an effective programme of work on a countrywide scale, a knowledge of the existent conditions in different parts of the country with regard to the various aspects of the industry as also of the little work that has already been carried out in different institutions, was a most essential pre-requisite. The monograph under review may be said to represent a very great advance in this direction which will provide a highly useful reference book for workers engaged on investigation problems relating to the *Gur* Industry as also those engaged on development work in this connection.

The book is an exhaustive treatise covering both the cane and palm *gur* industries and deals in considerable detail with their agricultural, technological and organisational aspects. The information presented therein relates not only to the different States of India but extends to Pakistan as well and it is to be hoped that this sister country would find the work equally useful.

The work consists of ten chapters dealing in different problems concerning the industry (which include a separate chapter on palm jaggery) and is followed by a host of useful tables, appendies and drawings. The frontispiece providing a *gur* map of India wherein are indicated the annual *gur* production figures for each district in the country, is a useful feature enabling the reader to appreciate at a glance the position of the *gur* industry in the country.

Chapter I provides statistical data in respect of such important aspects as the acreage under cane and its distribution, acre-yields, production of *gur* and its consumption, trade in *gur*, prices etc. These throw considerable light on the industry's position although the limitations attaching to such statistical figures have been rightly pointed out by the author. In Chapter II will be found a clear description of the various stages of the manufacturing process, commencing from the raw material and its maturity and harvest and extending right upto the final stages of finishing, storage and grading. Of special interest are the descriptions of various crushing mills in use, the comparative efficiencies of different vegetable clarificants and the details with regard to the preparation of such special products as cream jaggery, neutral *gur*, molassine *gur*, etc. The next two chapters (Chapters III and IV) discuss the important questions of the storage and grading of *gur* and a perusal thereof leaves the reader in no doubt as to their great importance for the future well-being of the *Gur* Industry. A review of recent research on storage methods and the schemes for a system of scientific grading clearly bring out what continued work may achieve in these directions. It is common knowledge that relatively inferior qualities of *gur* from centres enjoying a good reputation for quality may command a distinct premium in sale markets over better products from areas lacking such reputation. The importance of proper grading is thus quite apparent. The grading schemes described in the book take cognizance of the different important physical and chemical factors determining quality of *gur* but in order to arrive at a really comprehensive and reliable scheme applicable on an all-India basis, a thorough and detailed examination of the range of variation with regard to the various quality factors as also a proper and well-considered assessment of the relative importance to be attached to each factor must first be effected. The standards for evaluation of such physical factors as colour and texture must also be satisfactorily worked out. Chapter V furnishes a clear analysis of the cost of manufacturing cane *gur* in different parts of the country and the estimates of capital costs for installing *gur* manufacturing units of different capacities worked out at the Sugar Research and Testing Station, Bilari provide useful and accurate information for the guidance of prospective enterpreneurs wishing to operate units on modern lines. Chapter VI provides some scientific data in support of the popular notion regarding the nutritive value of *gur*. It would appear, however, that sufficient attention has not so far been directed towards this important problem and more exhaustive work on cane and palm *gur* of different varieties and origin with regard to their nutritional value in relation to protein, fats, mineral and vitamin contents is obviously indicated. Experiments should also be undertaken to verify the claims in respect of their medicinal properties made in Ayurvedic literature. In Chapter VII will be found a detailed statewise description of the existent condition of the *gur* industry in its different aspects which bring out marked zonal differences with regard to the condition of the industry

and provide an opportunity for the backward tracts to emulate the example of regions more advanced in respect of this particular industry. The chapter on research relating to *gur* making outfit (Chapter VIII) clearly shows what can be achieved by scientific research in the design of efficient crushers and furnaces. The drawings furnished at the end of the book are specially useful in this connection.

Chapter IX, dealing with the manufacture of palm jaggery, presents much information which although familiar to people in a few States like Bengal and Madras, will be indispensable for the guidance of those who will be responsible for starting this industry in the other States of India where palms have so far been tapped only for toddy.

The author's recommendations (Chapter X) with regard to intensification of research and development work and the setting up of an All India *Gur* Development Board supplemented by *Gur* Development organisations in every State possessing a sizeable *gur* industry cannot be too strongly emphasised. These will undoubtedly provide a fillip to the future well-being of this very important agricultural industry.

It appears, however, that there has been a considerable lag between the preparation of the book and its publication with the inevitable result that the latest developments have not found their way in an otherwise comprehensive monograph. The use of obsolete terminology (such as *Province* or *Presidency*) persists in the work which may be rectified in subsequent editions. The book is nicely and artistically got up and although reasonably priced for its size and quality, it is to be hoped that means will be found for reducing the cost still further in order to ensure maximum distribution. A Hindi translation of the work will render it available to large sections of people vitally intersted in the Industry. (K. L. K.).

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Instruction to Authors

Articles intended for *The Indian Journal of Agricultural Science* should be accompanied by short popular abstracts of about 330 words each.

In the case of botanical and zoological names the International Rules of Botanical Nomenclature and the International Rules of Zoological Nomenclature should be followed.

Reference to literature, arranged alphabetically according to author's names, should be placed at the end of the article the various references to each author being arranged chronologically. Each reference should contain the name of the author (with initials), the year of publication, title of the article, the abbreviated title of the publication, volume and page. In the text, the reference should be indicated by the author's name, followed by the year of publication enclosed in brackets; when the author's name occurs in the text, the year of publication only need be given in brackets. If the reference is made to several articles published by one author in a single year these should be numbered in sequence and the number quoted after year both in the text and the collected references.

If a paper has not been seen in original it is safe to state 'original not seen'. Sources of information should be specifically acknowledged.

As the *format* of the journal has been standardized, the size adopted being crown quarto (about $7\frac{1}{2}$ in. $\times 9\frac{5}{8}$ in. cut), no text figure, when printed should exceed $4\frac{1}{2}$ in. $\times 5$ in. Figures for plates should be so planned as to fill a crown quarto page, the maximum space available for figures being $5\frac{1}{4}$ in. $\times 8$ in. exclusive of that for letter press printing.

Copies of detailed instructions can be had from the Secretary, Indian Council of Agricultural Research, New Delhi.